Winter Expedition to the Southwestern Kara Sea - Investigations on Formation and Transport of Turbid Sea-Ice

Winter Expedition in die südwestliche Kara See - Untersuchungen über Bildung und Transport von Sediment-beladenem Meereis

---

By Dirk Dethleff, Peter Loewe, Dominik Weiel, Hartmut Nies, Gesa Kuhlmann, Christian Bahe and Gennady Tarasov

Ber. Polarforsch. 271 (1998)
ISSN 0176 - 5027

Winter Expedition to the Southwestern Kara Sea - Investigations on Formation and Transport of Turbid Sea-Ice

Winter Expedition in die südwestliche Kara See - Untersuchungen über Bildung und Transport von Sediment-beladenem Meereis

---

Dirk Dethleff
GEOMAR Research Center for Marine Geosciences, Wischhofstr. 1-3, D-24148 Kiel, Germany.
e-mail: ddethlef@geomar.de

Peter Loewe
Federal Maritime and Hydrographic Agency, Postfach 301220, D-20305 Hamburg, Germany.
e-mail: peter.loewe@m5.hamburg.bsh.d400.de

Dominik Weiel
GEOMAR Research Center for Marine Geosciences, Wischhofstr. 1-3, D-24148 Kiel, Germany.
e-mail: DWeiel@t-online.de

Hartmut Nies
Federal Maritime and Hydrographic Agency, Postfach 301220, D-20305 Hamburg, Germany.
e-mail: hartmut.nies@m3.hamburg.BSH.d400.de

Gesa Kuhlmann
GEOMAR Research Center for Marine Geosciences, Wischhofstr. 1-3, D-24148 Kiel, Germany.
e-mail: gkuhlman@geomar.de

Christian Bahe
Federal Maritime and Hydrographic Agency, Postfach 301220, D-20305 Hamburg, Germany.
e-mail: hartmut.nies@m3.hamburg.BSH.d400.de

Gennady Tarasov
Murmansk Marine Biological Institute, 17 Vladimirskaya St., Murmansk, 183010, Russia.
e-mail: mmbi@mun.rospac.ru

Winter Expedition to the Southwestern Kara Sea, Content

1. Course of the Expedition

1.1 From Kiel (Germany) to Amderma (Siberia)

The **KaBaEx** '97 (**Ka**ra and **Ba**rents Seas **Ex**pedition 1997) to the Siberian Kara Sea was carried out from April 1 to 25, 1997. While the scientific crew, consisting of Dirk Dethleff, Peter Loewe, and Domink Weiel, started on April 1 from Hamburg, the container with the expedition equipment was sent by cargo vessel and lorry from Kiel over Kemi and Rovaniemi (Finland) to Murmansk (Russia) already two weeks before (Fig. 1).

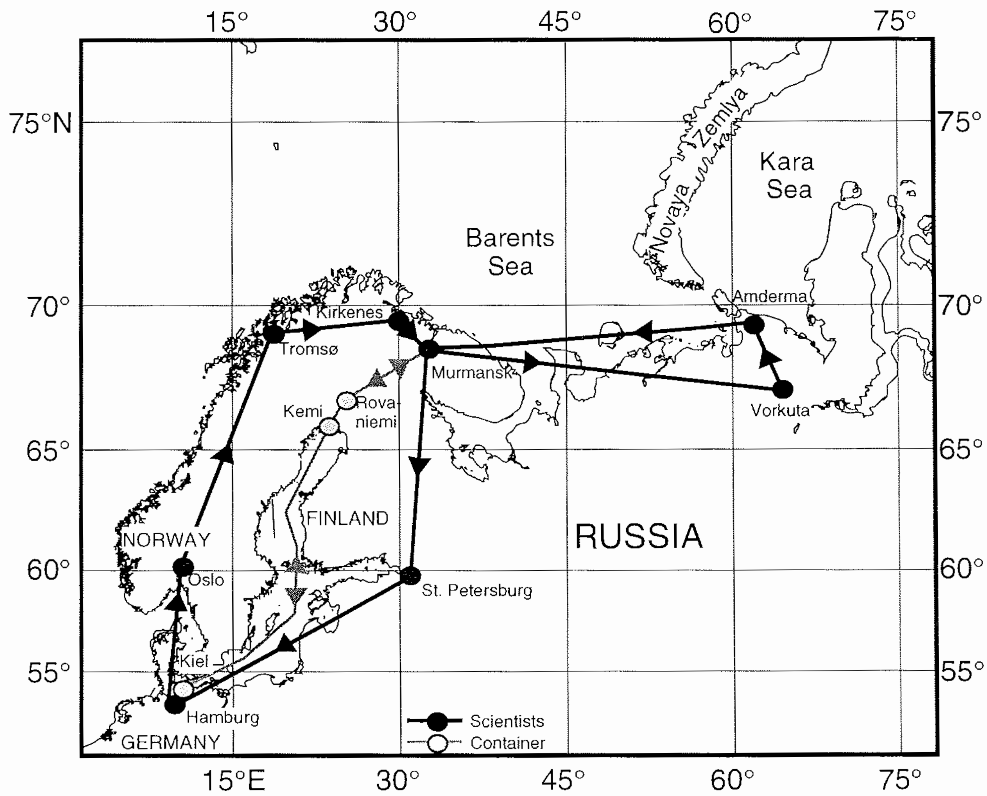

Fig. 1: Course of the expedition.

The scientists accessed Murmansk over Oslo, Tromsø, and Kirkenes (Norway). From Hamburg to Kirkenes we used the aircraft, while - after crossing the Norwegian/Russian border east of Kirkenes on foot - the last part of the journey to

Murmansk was undertaken in a van provided by the Murmansk Marine Biological Institute.

After 8 days of final preparations we left Murmansk by aircraft on April 9 towards Vorkuta (Fig. 1). From Vorkuta we accessed Amderma by a Russian MI-8 helicopter on April 11.

On April 22, after 11 days of field and laboratory work, we left Amderma and reached Hamburg - passing Murmansk and St. Petersburg - on April 25. The container was sent back 4 weeks later through our Russian colleagues and reached Kiel at the end of May.

1.2 Background informations and purpose of the expedition

From October to June the Siberian shelf regions from the Barents Sea to the Chukchi Sea are characterized by recurring extended flaw leads, separating the landfast ice from seeward drifting ice (Fig. 2). Occurrence, maintainance and dynamics of the leads are mainly steered by regional atmospheric pressure conditions (e.g. Zakharov 1966, Martin & Cavalieri 1989, Dethleff et al. 1993). Accordingly, offshore winds cause lead-opening, while onshore blowing storms push the drift ice against the fast ice edge and thus, initiate the closure of the open water areas.

In an open lead, the relatively warm water is exposed to the cold atmosphere. The net upward heat flux results in formation of new ice which is advected off-shore and partly exported to the Central Arctic Basin and, thus, can considerably feed the Transpolar Drift System. Dense brines, rejected during ice formation, may contribute to the Cold Arctic Halocline, and to Intermediate- and Deep Water renewal.

Through turbulent hydrodynamic ocean/bottom interactions such as Langmuir circulation, thermohaline convection, wave-action and tidal currents, unconsolidated fine-grained surface deposits can be re-suspended and floated upward in the flaw lead areas. The material can be entrained into newly forming ice by the mechanisms of suspension freezing (e.g. Reimnitz et al. 1992) and filtration (Osterkamp & Gosink 1984, Dethleff et al. 1994). Since these hydrodynamic entrainment processes seem to activate preferably small grains, Arctic sea-ice sediments generally consist mainly of silt and clay sized clastic material with a mean grain size in the medium to fine silt range (e.g. Kempema et al. 1989, Larssen et al. 1987, Dethleff et al. 1993, Reimnitz et al. 1993a, Nürnberg et al. 1994). The incorporated sediments will be transported via the Transpolar Drift System towards the North Atlantic where they are released due to local ice-melt.

Extremely little is known about the origin and pathways of turbid sea-ice produced over the Kara Sea shelf and, in particular, in coastal flaw leads. This report investigates sedimentological and mineralogical tracers such as quantitative and qualitative sample composition, clay mineral abundances and silt size distribution etc. in shelf surface deposits, suspended particulate matter and sea-ice incorporations. The main objective is to identify and trace possible mechanisms of material resuspension, sediment entrainment into locally formed sea-ice and its subsequent regional and long range dispersal.

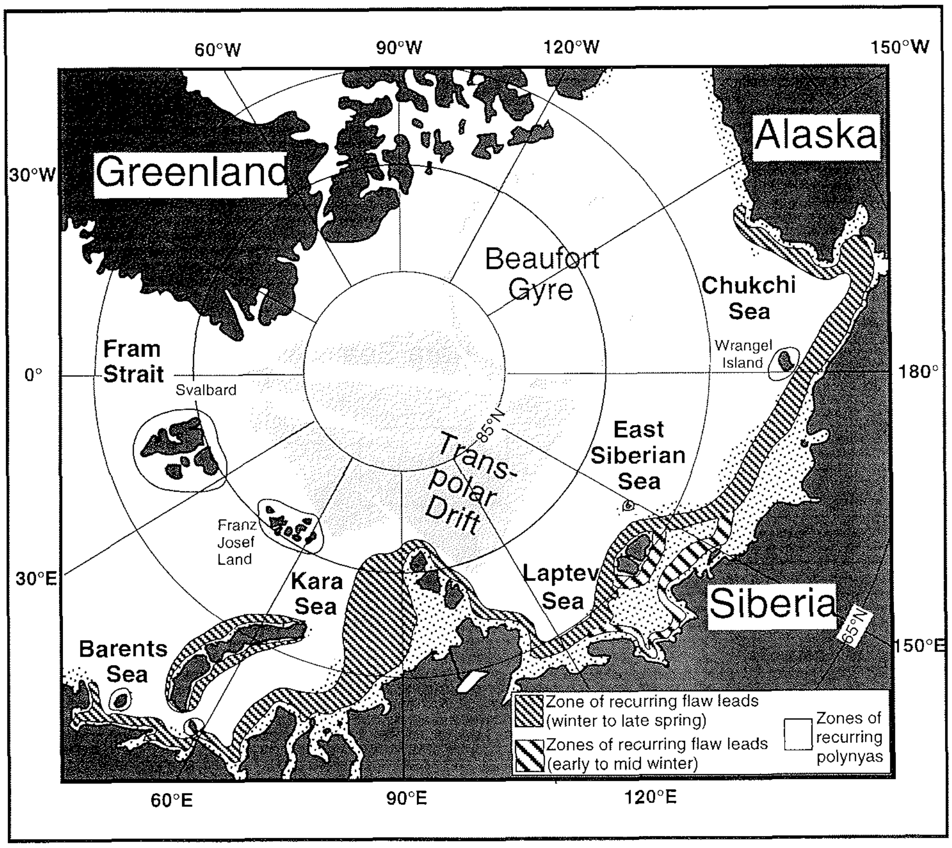

Fig. 2: Modern configuration of recurring Eastern Arctic flaw leads and polynyas between coastal fast ice and drifting ice (both not indicated here) as derived from NOAA/AVHRR and LANDSAT satellite images, Barnett (1991), Buzov (1991), Groves & Stringer (1991), Dethleff et al. (1993), Dethleff et al. (1994), Schwarz (1994), Dethleff (1995) and Pavlov & Pfirman (1995) and, after estimations of ice thicknesses based on 10-days integrated Russian ice charts for the period from 1972-1990 (AARI, St. Petersburg). The stippled off-coastal areas reflect the sea-ice-sediment sources <30 m water depth on the Arctic shelves as reworked from Reimnitz et al. (1992).

In order to accomplish these goals, during the joint Russian/German **KaBaEx** '97 winter expedition detailed oceanographic and sedimentological data were collected in the southwestern Kara Sea (Fig. 3). In particular, we i) studied the configuration of fast ice, flaw leads and drifting ice, ii) learned more about local oceanography and turbulent hydrodynamic processes of fine-grained sediment resuspension, iii) identified, quantified and qualified the entrainment of hydromechanically activated bottom material and atmospheric particles into locally formed new ice, and iv) quantified and traced the possible regional dispersion of ice inclusions into adjacent shelf seas, the Central Arctic and the northern North Atlantic Ocean supported by modeling results.

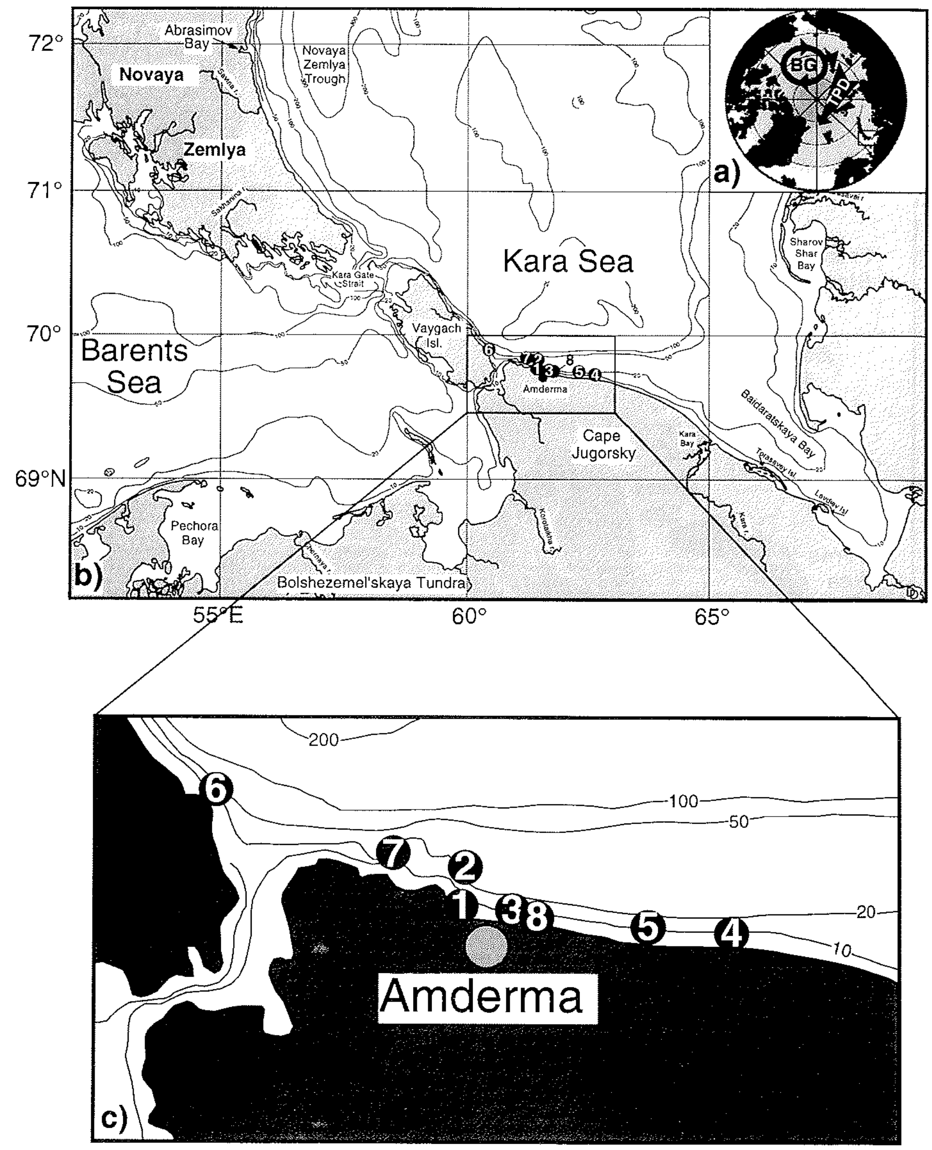

Fig. 3: Arctic overview chart (a), the SW Kara Sea and adjacent E Barents Sea (b), and the area of investigation (c). Sampling sites are indicated by dots. Water depths are given in m.

1.3 Area of investigation

The inner part of the Kara Sea between Novaya Zemlya, the Siberian mainland and Severnaya Zemlya may be regarded as a semi-enclosed Arctic shelf sea. Water depths widely range between 20 and 200 m (Fig. 3). The Novaya Zemlya trough has a depth of more than 400 m. Shallow, near coastal areas with water depths below 50 m are dominated by fine-grained surface deposits (Geogruppen AS 1994) and thus, provide optimum conditions for sediment resuspension and formation of turbid ice (compare Fig. 2).

The occurrence of flaw leads in the western Kara Sea along the northeastern coast of Novaya Zemlya and off the eastern coast of Vaygach Island (Fig. 4) is attributed to predominating westerly winds (e.g. Martin & Cavalieri 1989, Dethleff & Reimnitz 1996). The area east and south of Novaya Zemlya is - according to recent Russian investigations - characterized by very high probabilities of flaw lead recurrence (about 50 %; V. K. Pavlov, 1996, AARI St. Petersburg, pers. comm.). This makes these sites to the most important and interesting locations for investigations on turbulent processes of bottom/ocean/sea-ice interactions, sediment entrainment into newly forming ice and subsequent dispersion of incorporated clastic material - and attached pollutants - in the entire Arctic Ocean.

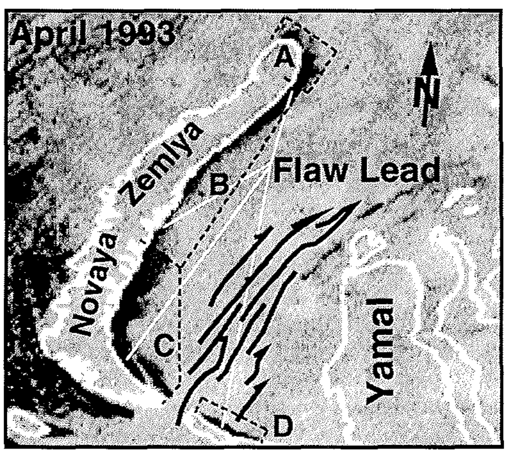

Fig. 4: NOAA 12 visible band satellite image from April 10, 1993 showing recurrent, coastal flaw leads in the ice-covered, western Kara Sea. Boxes A-C represent the east Novaya Zemlya lead sections (adapted from Martin & Cavalieri 1989), while box D contains the Amderma/Vaygach flaw lead investigated during April 1997 field work. The black traces represent sea-ice foreward trajectories based on climatic parameters (reworked from Nies et al. in prep.).

The salinity and temperature distribution in the southern and southwestern Kara Sea is mainly influenced by Atlantic water inflow from the Barents Sea through Kara

Strait, while the local river discharge is of minor importance (Pavlov & Pfirman 1995). Temporary inflow of river water from the Barents Sea through the Kara Strait can be expected by the Pechora Current (Pfirman et al. 1997a). During summer, surface temperatures and salinities in the investigation area range from 2-10 °C and 25-30 psu, respectively, with a pronounced halo- and thermocline in the upper water column (Pavlov et al. 1994). Towards the bottom, salinities increase to as much as >34 psu and, temperatures decrease to as low as -1.8 °C. During winter, the vertical salinity and temperature distribution in the water column is generally uniformly stratified since ice formation and subsequent brine rejection cause efficient mixing.

Informations on the oceanic current patterns in the western and southwestern Kara Sea are contradictive. According to e. g. Pavlov & Pfirman (1995) and also deduced by Nürnberg et al. (1995) from clay mineral distribution patterns in bottom sediments, the surface water is dominated by a wind- and thermohaline induced cyclonic circulation pattern, which consists of the southward directed, near-coastal Eastern Novaya Zemlya Current, and the northward, off-coastal Yamal Current. However, as shown by King et al. (1997) and Johnson et al. (1997) through ice-buoy trajectories and acoustic-doppler-current-profiler (ADCP) data, the water transport along the east coast of Novaya Zemlya down to depths of as much as 350 m is generally northward directed with no indication for water inflow to the Kara Sea around the northern tip of Novaya Zemlya. This could also be shown through modeling results (Harms 1997). Thus, the postulated counter-clockwise surface-current pattern in the western Kara Sea, which is frequently cited in Russian and international literature, could not be corroborated in recent times.

2. METHODS AND MATERIAL

2.1 Sampling methods, material obtained and field measurements

The sample material was collected at 8 sites along the coast of Cape Jugorsky and close to Vaygach Island, southwestern Kara Sea (Fig. 3, Table 1, annex). Stations 1, 2, and 3 were located close to the coast on the fast ice or attached drift ice with fast ice character. The sampling sites were accessed by scidoos and snow cats. Stations 4, 5, and 6 were located close to the lead (≈ 200-300 m) on fast ice-attached drift ice, while stations 7 and 8 were chosen on a drift ice floe in the flaw lead and directly on the edge of fast ice, respectively. Stations 4-7 were accessed by a Russian helicopter of the MI-8 type.

Bottom sediments

Shelf surface deposits for sedimentological purposes were sampled using an EKMAN-BIRGE grap constructed by HYDROBIOS, Kiel, Germany. The gear was lowered to the shelf bottom through the penetrated ice cover. Additionally, we used a small stainless steel gravity corer with macrolone tube, which was designed for the use through a 10 cm ice bore hole.
A total of 15 surface (interval: 0-5 mm) and 7 mixed surface/subsurface (interval: 0-30 mm) sediment samples was obtained at sites 1-8 (Fig. 3, Table 2). The sediments

obtained were filled in plastic bottles and containers and stored under cold or freezing conditions varying between +4° and -15°C.

Suspended particulate matter (SPM)

A total of 22 SPM samples was collected at stations 1-8 either by Niskin bottle or sediment traps i) under the fast ice cover, ii) at the edge of fast ice (flaw lead) and iii) under drift ice floes in the flaw lead. Two samples were each taken in three different water depths: a) close to the surface, b) in the middle of the water column and c) near to the shelf bottom (compare Table 1 and 2). One of the subsamples was concentrated on mixed-ester membrane filters (0.45 µm pore diameter) in the field lab while the other sample was conserved at temperatures between +4 and -15° C for further investigation in the home laboratory.

Sea ice sediments

Ice cores were taken at stations 1-7. The cores were divided into chunks of roughly 10-15 cm length and stored in plastic bags under freezing conditions. After microwave-melting the core sections were filtered using pre-weighted, mixed-ester membrane filters with 0.45 µm pore diameter. The filtered material was frozen and dried for further sedimentological investigations.

Additionally, ice-sediments were collected from pressure ridges and turbid core sections at stations 2, 4, 5 and 7. The sampled material was filled in plastic bottles and stored at low temperature (+4° to +6° C) or under freezing conditions.

Particulate snow content

Snow was collected at stations 1, 2, 3, 4 and 6. The snow was melted and filtered in order to conserve the particle content for further sedimentological investigations.

Radionuclides

Water volumes varying between 76 and 93 l were collected at stations 1, 4 and 6 in order to determine ^{137}Cs and ^{134}Cs. The electric pumping system was stored in an insolated aluminum box particularly designed for the application in cold regions. The sampled water was filled into 100 l containers, acidificated with HCl down to a pH of as low as 2 and run over an exchanger raisin of potassium-hexacyano-ferrate-(II)-cobaltate(II) (KCFC), thereby absorbing Cs ions from sea water with a chemical yield of >95 %.

Mixed surface sediment samples (0 - 30 mm depth) of ca. 400 - 800 g w.w. - taken with the mechanic grab corer - were stored in plastic containers in order to determine also man-made Cs ions and different other man-made radionuclides such as e.g. Pu.

Conductivity, temperature and density measurements in the water column (CTD)

2 different battery powered SIS-sondes (CTD plus 1000, SIS Meeres- und Umwelttechnik GmbH, Kiel, Germany) were used to obtain CTD-profiles beyond the ice cover and in the flaw lead. Measurements were carried out at each station.

Reliable CTD profiles were obtained at 6 stations, 3 of which were recorded under fast ice (#2, #4, #5), 2 under drifting ice (#6, #7), and 1 (#8) in the flaw lead (compare section 3.2).

2.2 Laboratory methods

2.2.1 Sedimentology

Shelf surface deposits and sea-ice sediments were prepared for smear slide analyses in order to estimate the quantitative and qualitative sample composition under the microscope.

Further laboratory investigations include:
- wet sieving and Atterberg separation of coarse, silt and clay fractions of shelf surface deposits and sea-ice incorporated material
- qualitative and quantitative component analyses of coarse fractions
- granulometric silt analysis (LaserGranulometer, SediGraph) of both shelf surface deposits and sea-ice sediments
- qualitative and quantitative component analyses of silt fractions under the Scanning Electron Microscope (SEM)
- X-ray diffractometry of clay fractions
- granulometric analysis, and qualitative and quantitative component analyses of SPM and particulate snow content.

2.2.2 Radionuclide determination

The shelf surface deposits obtained for radionuclide measurements were freeze-dried and homogenized. Both sediment and dissolved (ion-exchanged) samples were filled in beakers with a calibrated geometry. For spectrometric analysis we used high purity germanium detectors (HPGe). The samples were analyzed for artificial gamma-emitting radionuclides such as $^{137,134}Cs$, ^{60}Co, ^{241}Am and different natural radionuclides.

3. Preliminary Results

3.1 Ice conditions in the investigation area

According to the chief of the Amderma Hydrometeorological Survey Station (pers. com. Andrej Anatoliwitsch), the 1996/97 freezing period in the southwestern Kara Sea began on December 10, 1996, and thus was extremely late as compared to former years. Additionally, the winter temperature regime was relatively "mild" resulting in local ice thicknesses not significantly exceeding 1 m.

3.1.1 Fast ice

According to unpublished NOAA ice-charts (http://www.natice.noaa.gov), during winter the inner part of the Kara Sea is completely ice covered (Fig. 5). Generally, a coastal fast ice band develops which has a width of roughly 10 km or even less and thus, is relatively narrow as compared to the Laptev Sea (see Dethleff et al. 1993; Reimnitz et al. 1994). In case of offshore winds, the fast ice edge is bordered by flaw leads. In certain years (e.g. January 1998, compare http://www.natice.noaa.gov) no fast ice occurs along extended parts of the Cape Jugorski and Novaya Zemlya coast line in the western Kara Sea so that shore leads or polynyas develop instead of flaw leads.

During April 1997 field work, the fast ice canopy in the Amderma region was extremely narrow and partly had a width of only 500 m to 1.5 km. The edge of fast ice followed roughly the 10-15 m isobath thereby running in much shallower water as compared to extended areas of the eastern Kara Sea and most parts of the Laptev Sea. East of Amderma, a coastal section of few km length revealed no coastal fast ice (compare Fig. 5) and the flaw lead (in this case a shore polynya) extended to the shore.

The fast ice consisted generally of first year ice. The uppermost core section (10-15 cm) was dominated by granular ice, while the lower sections were of columnar ice. Bulk core thicknesses varied between 70 and 90 cm (stations 1 and 2) and, culminated - at a site of likely rafted first year ice - in 1.7 m thickness at station 3 (Table 1). The edge of fast ice was often bordered by 3 - 6 m high pressure ridges or extended compressional ice fields. This is also an essential difference to the Laptev Sea, where a general lack of pressure ridges was reported along the fast ice edge (Dethleff et al. 1993; Reimnitz et al. 1994). Hummocks of as much as 6 m height in areas of roughly 10-15 m water depth (or even below) might have led to formation of stamukhi thereby stabilising the coastal ice against onshore compression and dilational breakaways. However, we often could not clearly distinguish between ridged fast ice and compressed former drift-ice fields; this led to the assumption that the true width of the coastal fast ice partly might differ from what is indicated in NOAA ice charts.

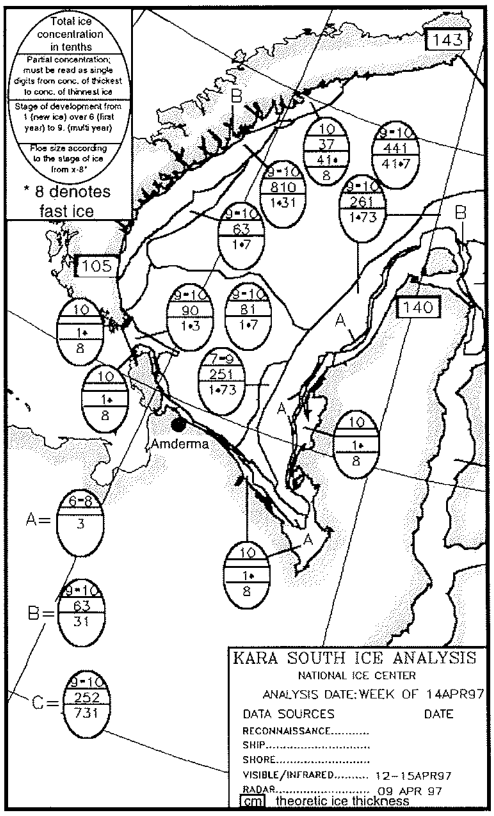

Fig. 5: NOAA ice chart from field work period in April 1997. Local Amderma and Vaygach Island ice conditions reveal a coastal fast ice zone and adjacent drift ice of 7-10 tenths coverage (see egg-code in the upper left corner). For more detailed information on egg codes see NAVY/NOAA Joint Ice Center atlasses (1975-1993) or NOAA web site "http://140.90.54.35/".

3.1.2 Flaw leads

Open water between fast ice and drifting ice occurred during the entire period of field work. In the first part of field work, the air temperature ranged between -10 and -20°C thereby enhancing temporarily new-ice formation over open water in the roughly 1-2 km wide Amderma/Vaygach flaw lead. The new ice was collected in surface streaks together with small drift ice floes and advected offshore towards the drift ice. The parallel surface streaks of collected ice crystals and small floes indicated convergent helical oceanic vortices promoting mixing of the water column which might lead to resuspension of bottom material and formation of turbid sea-ice (see Dethleff 1995a).

Due to ice melt induced by atmospheric temperature increase, and additionally strong local offshore winds, in the second part of field work the width of the (former) flaw lead increased to as much as 30-40 km. The heat flux reversal due to the warm atmosphere prechuded further ice formation. On the last day of field work, the wind changed from offshore to onshore directions thereby causing the rapid closure of the open water within roughly 24 hrs.

3.1.3 Drift ice

Drift ice occurred in and off the Amderma/Vaygach flaw lead in varying thicknesses (0.68 to 0.89 m), floe sizes and stages of development. The drilled cores consisted in the upper 10-15 cm of granular ice, and in the lower part of columnar ice. While the sampled 300-500 m large level ice floes consisted of "clean ice" with no or only little visible sediment inclusions, the marginal floe pressure ridges contained extremely turbid sea-ice. This was also observed during R/V "POLARSTERN" ARKXIII/2 cruise in the summer of 1997 in the central Arctic and in northern Fram Strait.

At station 4, off the edge of fast ice, we sampled wet, unconsolidated and significantly sediment-laden former lead ice. On contrary, the directly adjacent fast ice contained less particulate inclusions. We assume that the sediment-laden new ice was formed under turbulent conditions over shallow water depths (roughly 11 m) in the flaw lead and then pressed against the fast-ice edge through onshore winds.

The offshore drift velocity of large ice floes was determined by use of a GARMIN GPS (Global Positioning System). The velocities varied between few m and several 100 m/h, culminating in 700 m/h in the wide open Amderma lead off Vaygach Island due to southerly winds.

3.2 Oceanography

Little is known in western literature about the vertical salinity distribution on the shallow Siberian shelves and - particularly - in the flaw lead areas during winter. Churun & Timokhov (1995) reported data of vertical winter water mass distribution of the western Laptev Sea showing pronounced thermo- and haloclines due to perennial Khatanga and Lena river discharge. Bottom salinities increased partly to as much as 35 through brine rejection subsequent to ice extraction.

For the western Kara Sea, also few winter data are available on water mass stratification (e.g. Pavlov & Pfirman 1995) which are restricted to the Novaya Zemlya trough north of the investigation area (compare Fig. 2). A significant salinity increase from 32 to 34 was observed at around 30-40 m water depth indicating the continuous influence of the Ob and Yenisej River discharge on the structure of the upper local water column (surface layer).

Our preliminarily processed winter salinity profiles (Fig. 6) from the southwestern Kara Sea show no strong riverine fresh water influence in the upper water column off the coasts of Cape Jugorsky and Vaygach Island. Without going too much into

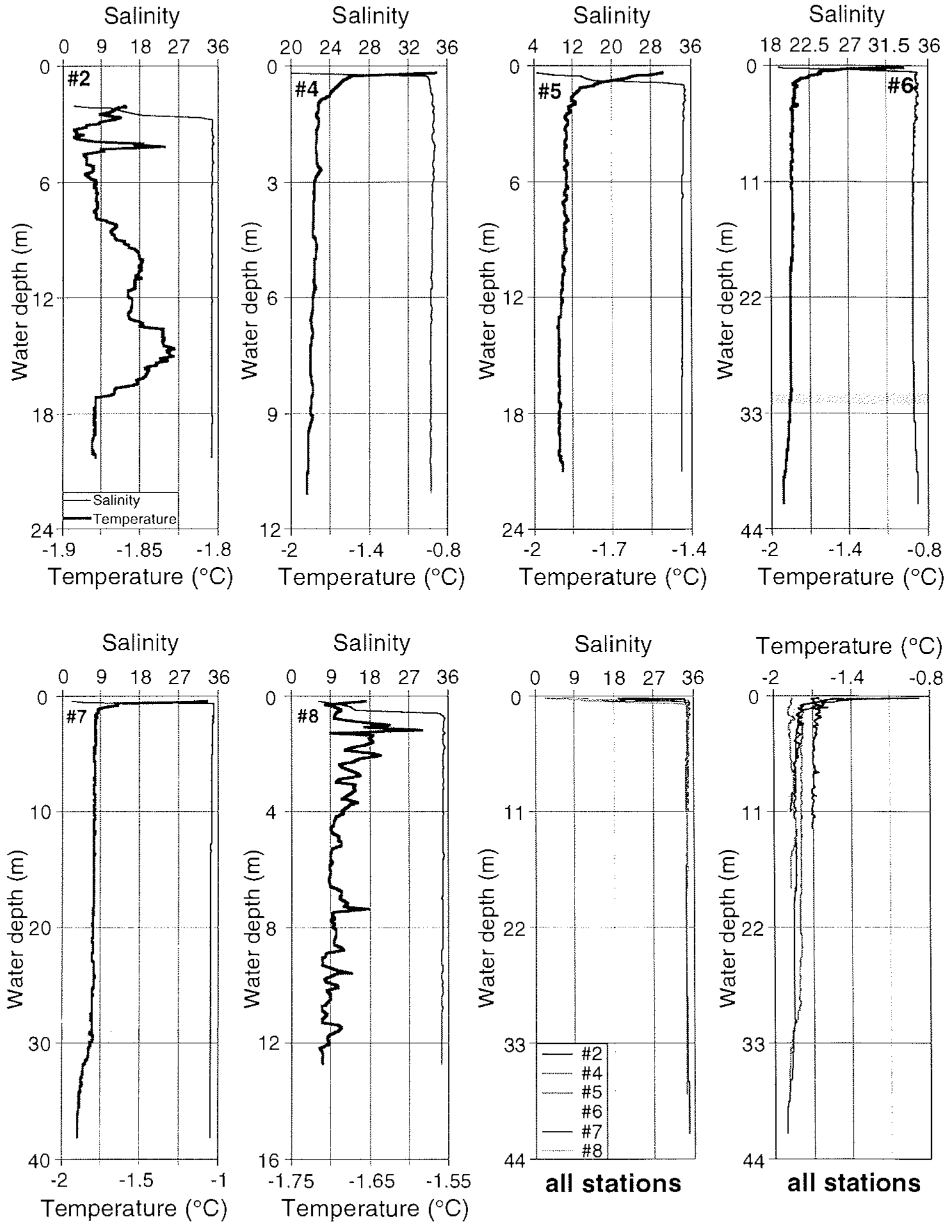

Fig. 6: Salinity and temperature profiles from the area of investigation.

detail, we can say that the salinities generally tend to increase strongly at the uppermost meters, and then show a uniform distribution from the surface towards the shelf bottom at shallower water depths (#2, #3, #5), thereby displaying no indications for expressed halo- or thermoclines. This points - in first approximation - to a well mixed water column under the fast ice cover. The salinity profiles at stations 6 and 7 slightly differ from the above pattern by showing a distinct halo- and thermocline at roughly 30 m water depth with decreasing temperatures and increasing salinities towards the bottom (indicated by a horizontal grey bar, Fig. 6).

At a first rough glance, the salinity profile of the flaw lead (#8) generally represents a uniformly stratified - and thus well mixed - water column from 1 m down to 13 m water depth. However, taking a closer look to the data sets, both temperature and salinity values *scatter* and *decrease* towards the bottom. That means, the water becomes colder downwards despite decreasing salinity with increasing water depth. The enhanced - and flickering - temperature in the upper water column might have been due to intensified sun insolation promoting heating and the formation of microturbulences. The slightly fresher - but colder - bottom water might be due to stratification reversal through turbulent mixing of low salinity, cold surface water with denser bottom water during an extreme freezing event in the lead area previous to our sampling period.

3.3 Sedimentology

3.3.1 Shelf bottom deposits

According to Geogruppen AS (1990) the surface deposits in the investigation area consist mainly of silty sediments with varying percentages of sand and clay. This was generally confirmed by preliminary smear slide estimates of the sampled material (Table 3, Fig. 7). Accordingly, the grain size distribution of surface sediments in the investigation area vary between silt and sand, while the clay fraction is generally less abundant. Highest silt and sand portions on bulk sediment amount to as much as 85 % or even more, whereas the clay fraction generally does not exceed 20 % and often lies below 10 or even 5 %.

The qualitative sample composition reveals high percentages (65-80 %) of mainly angular to subrounded quartz and feldspar, while rounded clastic particles (e.g. glauconite), rock fragments, mica, biogenic components and opaque minerals are less abundant or even absent (Fig. 8). Angular to subrounded clastic particles are more abundant in the coarse fraction than in the silt spectrum.

3.3.2 Suspended particulate matter (SPM)

Very little is known about SPM content in Siberian shelf waters during winter. Dethleff (1995a) reported winter (April) SPM concentrations of 1.24 mg/l in the eastern Lena river pro-delta, Laptev Sea. The concentrations decreased to as low as 0.24 mg/l along a 500 km northward surface water transect from the delta towards the Central Arctic Ocean.

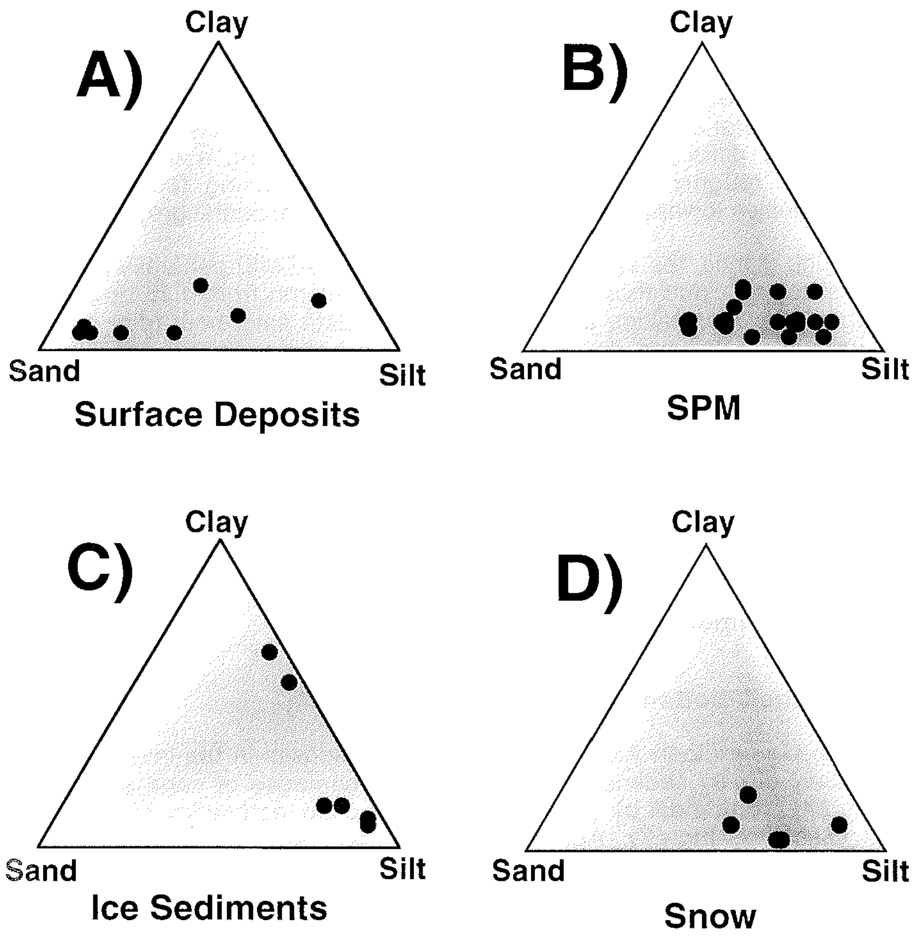

Fig. 7: Sand-silt-clay distribution of surface deposits, suspension load, sea-ice sediments and snow entrapped particulate matter.

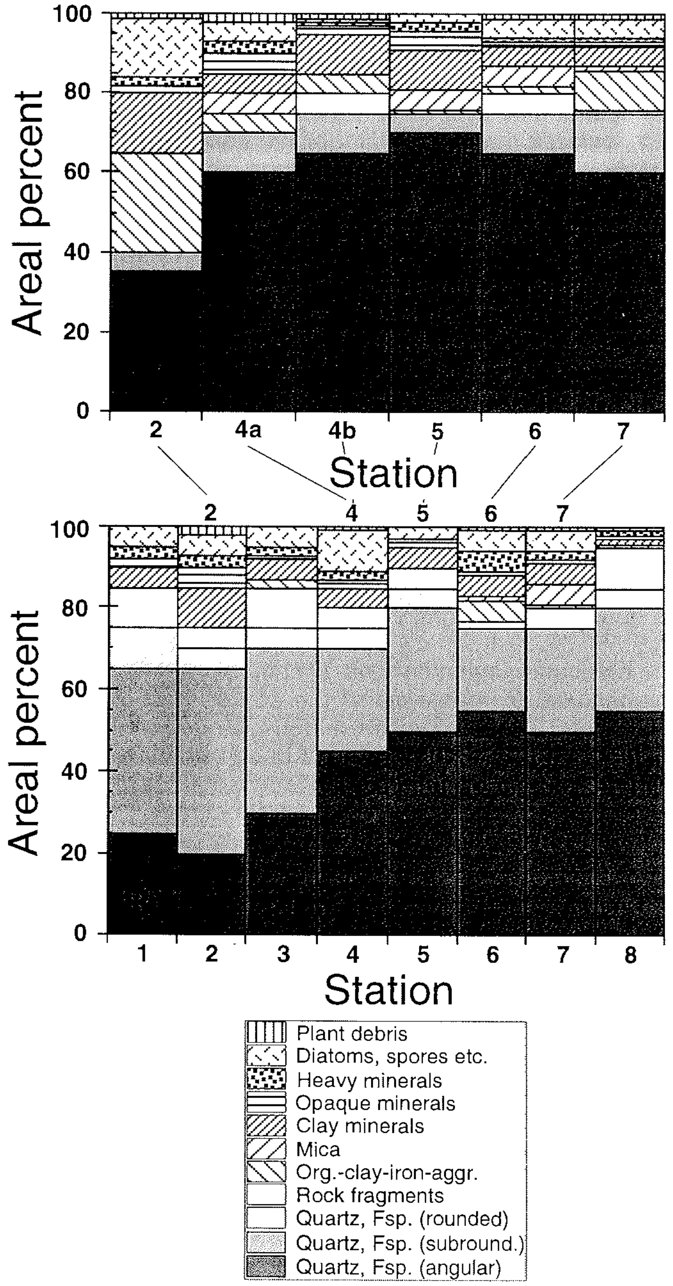

Fig. 8: Quantitative and qualitative composition of surface deposits and sea-ice sediments in the field work area. A) denotes sea-ice sediments, while B) represents shelf surface deposits.

At the KaBaEx fast ice stations nos. 1, 2 and 3, the SPM concentrations ranged from 0.55 mg/l in the under-ice surface layer to 13.77 mg/l in the nepheloid layer close to the shelf bottom (Fig. 9, Table 4). No such strong gradient was observed under the drift-ice at stations 5, 6 and 7, where the concentration of suspended material even tended to decrease towards the bottom. Under the compressed new-ice field off the fast ice edge at station 4, the SPM concentrations showed high values in surface waters (4.16 mg/l) and then decreased towards the bottom to as low as 1.87 mg/l. Our first assumption was that the enhanced SPM concentration in the under-ice surface water was due to melting and ridging-induced sediment release from the tilted, turbid ice floes. However, the SPM composition and the degree of particle roundness did not bear resemblance to the ice-entrained material, but nearly equalled the local shelf surface deposits (see below).

Highest SPM concentrations were found in the sediment traps deployed at the fast ice edge (station 8, flaw lead) for a period of about 10 hrs. The content of particulate matter decreased from 38.33 mg/l at the water surface to roughly 23 mg/l close to the bottom. Most of the material trapped consisted of macroscopic copepods and other planctonic and nectonic organisms. The enhanced concentrations of living organic material, particularly in the uppermost part of the water column, resulted from favorable living conditions due to algae bloom, long daylight conditions and radiative heat gain of the surface water during the sampling period. In surface and bottom waters we detected traces of spherical fly ashes.

First results from binocular investigations (Table 5) reveal that the SPM shows generally silty composition. Percentages of the coarse fraction vary and clay sized material is less abundant. The silt fraction is dominated by angular quartz particles, whereas the coarse fraction contains partly enhanced abundances of fluffs (#1, #2), dark minerals (#6), copepods (#8) and particularly (well)rounded clastic material (#3, #4, #5, #6, #7). Surprisingly, at most of the latter sites we found higher abundances of rounded, coarse (≈100-500 µm) quartz particles close to the surface rather than in the middle of the water column and towards the bottom, where they actually *should* be expected. This points to a well mixed or even reversed water column stratification due to turbulences maintaining clastic particles of as much as 500 µm in diameter in suspension. The required current velocity of 40 to 50 cm/s to keep such large particles in suspension could be provided by local tidal current (Harms 1997).

At station 4, where the highest abundances of sand-sized, (well)rounded clastics occurred in the upper water column (Table 5), the same material was found in the local shelf surface deposits (Table 3) at 9 m water depth. However, no such particles were found in local ice cores and ridges. This points to different probable processes active at this shallow site during and after initial ice formation (reminder: this location was sited at the edge of the Amderma lead, which was closed by compressed, wet, not completely consolidated, and sediment-laden new ice shortly before sampling): i) despite of being available in the suspension load, the (well)rounded, coarse-grained particles were not entrained into newly forming ice through the mechanism of suspension freezing during open lead conditions; or ii) the (well)rounded material was not available in the SPM during initial ice formation in the lead area and was thus not entrained, or iii) the ice was formed at a different site. However, well rounded, large clasts are available at any site in the investigated area both in shelf surface deposits and the water column. The above will be discussed in further detail in section 4.1.

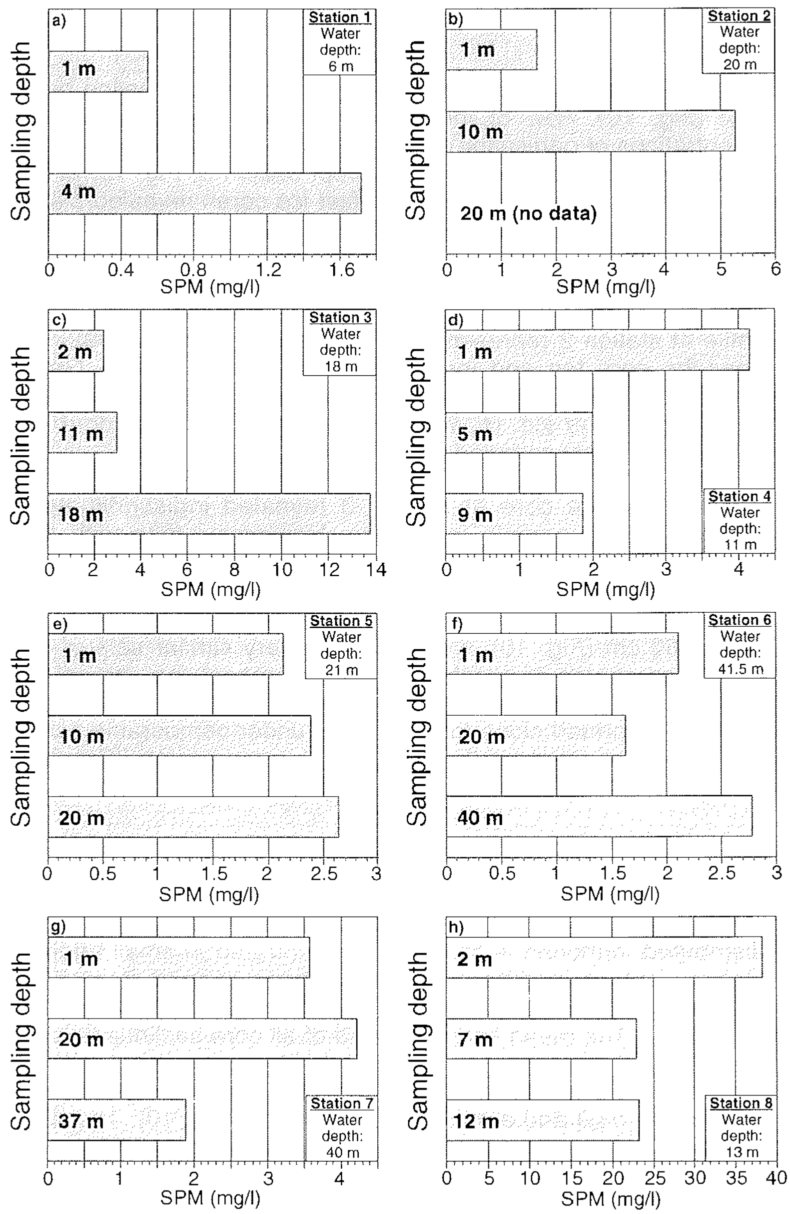

Fig. 9: Concentration of SPM at KaBaEx '97 sampling sites 1-8 (a-h). Water depths and nos. of sampling locations are indicated in the small shaded boxes.

3.3.3 Sea-ice inclusions and ice core salinity distribution

The sea-ice sediments obtained during KaBaEx '97 expedition represent a small - but worldwide unique - sample set of the Kara Sea.

Fast ice

The fast ice cores revealed no or only minor visible inclusions varying between 1.59 and 20.50 mg/l (Fig. 10). Few of the uppermost core sections showed slightly increased concentrations of particulate matter compared to the middle part of the fast ice cores, which contained less inclusions (except station 3, Fig. 10, at around 100 cm core depth). The lowermost sections of all fast ice cores revealed also increased material loads due to enhanced microbiological activity.

The salinities in the fast ice cores varied from 0.8 to 8.3. Highest fast ice salinities were determined at station 2 (Fig. 10), the lowest were measured at station 3. The ice-salinity profile at station 2 represents a ?-shape type (Eicken 1992) with salinity decreasing near the core top and increasing towards the bottom. Generally, the decrease of salinity towards the top of the ?-type profile is typical for retextured and brine-drainaged second year ice. However, in this case - and in some more cases reported below - we definitely sampled first year ice.

At first glance, the fast ice core at station 3 revealed indiscriminate scattering distribution of salinity and particle inclusions. However, along with the unusual thickness of 1.70 m, which cannot result from seasonal thermodynamic ice-growth, the vertical distributions of salinity and particles provide hints for ice rafting in an earlier stage of development. If we cut the ice core - theoretically - into two sections at the depth of 70-80 cm (Fig. 10), we obtain two very similar sets of curves. The resemblance of these curves suggests that they represent the vertical salinity and sediment distributions of two formerly individual, roughly 80 cm thick floes or pieces of fast ice, which were formed close to each other under comparable oceanographic conditions and then were piled up through lateral compression. The shape of the salinity distributions is of ?-type for both core sections.

Drift ice

The drift ice (Fig. 10) was generally more turbid than the fast ice. Most of the material was concentrated in the uppermost 30-60 core cm. The visible, fine-grained material was cloudy distributed, enriched in layers or concentrated in small aggregates. The particulate matter content in different core sections ranged from 2 to 35 mg/l reaching an extremum of 140 mg/l at station 5 (core section 12-22 cm, Fig. 10, compare also Table 3). The mean sediment load of all core sections was 9.91 mg/l.

At station 4 we found visible sediment concentrations over the entire ice core with a minimum of roughly 10 mg/l and a maximum of 35 mg/l (Fig. 10). The drift ice cores at stations 5, 6, and 7 showed particulate matter contents below 10 or even 5 mg/l. The lowermost sections of all ice cores generally revealed increased material loads as compared to the middle part, which was again due to enhanced microbiological activity.

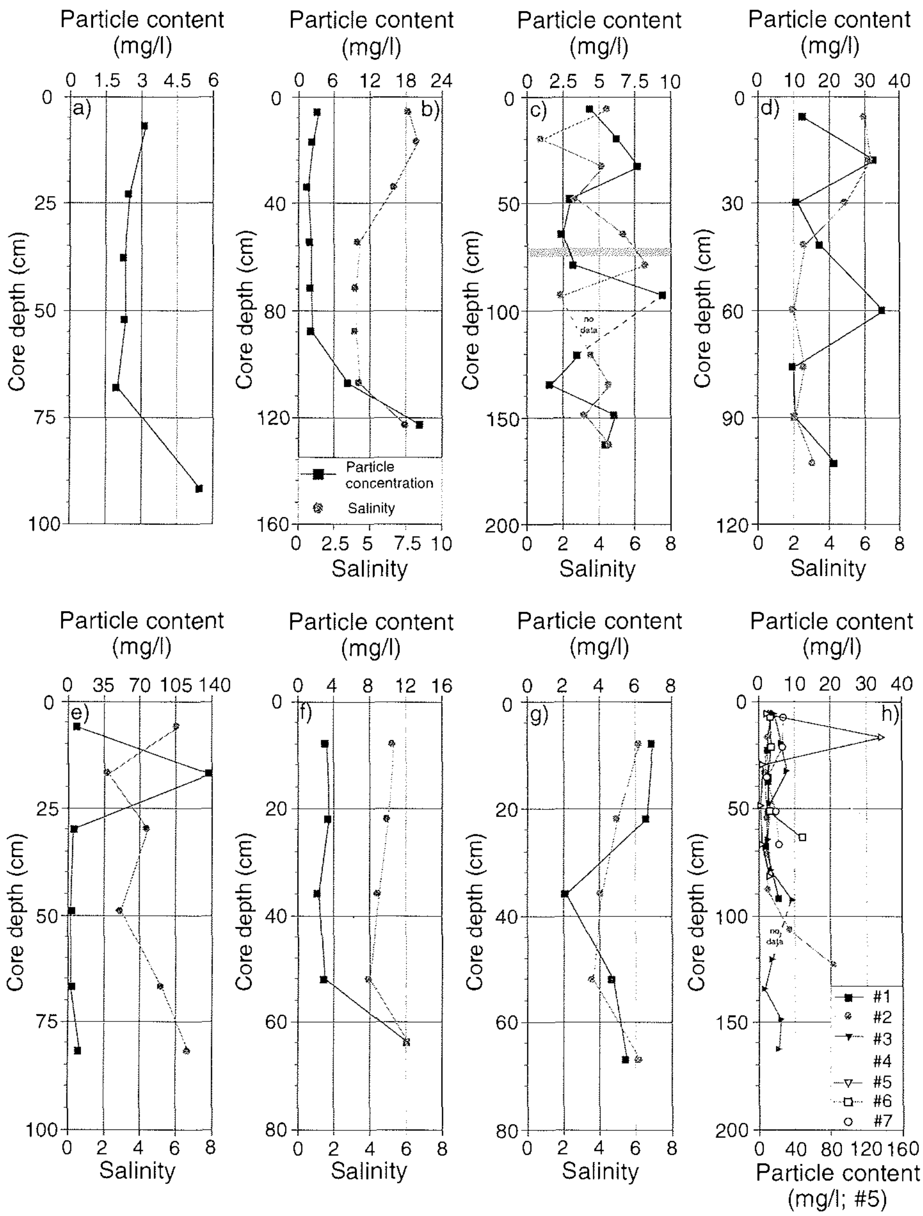

Fig. 10: Concentration of particulate matter and salinity distribution in ice cores (Fig. a to g refer to stations 1-7; Fig. h displays all stations, where the lower x-axis refers to station 5 only). The horizontal grey bar in Fig. c represents the potential level of rafting.

Drift ice salinities varied from 2.0 to 6.7 and thus were in a smaller range than fast ice salinities. Highest salinities were measured in the uppermost core sections of station 4 and in the lowermost chunk of station 5 (Fig. 10). The drift ice salinity profiles were of C-, I- and ?-type shapes (compare Eicken 1992).

The salinity distribution at station 5 (Fig. 10) represents a less pronounced C-shape profile with slightly increasing values towards the top and the bottom. The C-type is considered typical of growing young or first-year Arctic sea-ice (compare Eicken 1992). Stations 6 and 7 (Fig. 10) reveal less pronounced C-shape profiles, which could also be interpreted as I-shaped. According to Eicken (1992), the I-type has nearly constant salinities throughout the core or the salinity even decreases steadily towards the bottom. This was the case at stations 6 and 7 except for the lowermost core sections.

The ice core at station 4 (Fig. 10) reveals the most interesting distribution of salinity and particle content. In first approximation, the salinity distribution can be classified as ?-type shape (compare Eicken 1992). Due to the steady salinity decrease towards the bottom, the curve may also be interpreted as I-type. According to Eicken (1992), a salinity drop by a factor of 2 from the top of the core towards the bottom results from the insulation efffect of snow accumulation and increasing oceanic heat flux during winter. On the other hand, a substantial salt loss towards the core bottom may also be due to short-term, rapid ice growth followed by insignificant growth or thickness change for the rest of the season. Since the ice core at station 4 revealed the highest particle content in the upper 60-70 cm of all cores (except: cm 12-22, #5), we assume that the ice at station 4 was formed rapidly under extreme, turbulent freezing conditions in the open lead thereby promoting the incorporation of (re)suspended particulate matter.

Sedimentology of sea-ice inclusions

Smear slide analyses of particulate matter extracted from fast- and drift-ice cores reveal extremely high percentages in silt and clay fractions (85-95 %), while the sand fraction generally is underrepresented (compare Table 3, Fig. 8). According to our estimates, as much as 80 areal% of the bulk fraction is composed of angular and subrounded clastic material (mainly quartz and feldpar) with highest abundances in the silt fraction, which represents on average 64.2 % (30-85 %) of the material. Well rounded particles do generally not occur in the sea-ice sediments.

Organic-clay-iron aggregates, clay minerals and microorganisms partly appear in slightly enhanced portions of 5-25 %. Other clastic material or biogenic components, such as heavy and opaque minerals as well as plant debris, are generally infrequent. The less abundant coarse fraction (5-15 %) is mainly composed of aggregates consisting of fine grained material, idiomorphic gypsum minerals and varying biogenic material.

3.3.4 Particulate snow content

Concentrations of particulate matter in the Arctic Ocean snow cover vary between 0.4 mg/l in the central Amerasian Basin (Mullen et al. 1972, Darby et al. 1974) and as much as 170 mg/l on the near coastal Laptev Sea fast ice (Dethleff 1993).

However, despite partly considerable concentrations of particulate matter in Arctic snow, a significant contribution of aeolian dust to sea-ice sediments was ruled out by most authors (e.g. Larssen et al. 1987, Pfirman et al. 1990, Wollenburg 1993, Dethleff 1995a).

The content of particulate matter in snow of the investigation area ranged from 1.87 to 11.37 mg/l (compare Table 4) with a mean of 4.52 mg/l. Highest concentrations occurred at station 1 in closest vicinity to the coast line, while lower particle contents were determined at those stations which were located more remote from land. As already proposed by Dethleff et al. (1993) for the Laptev Sea, decreasing particle concentrations in snow with increasing distance from the coast are due to the mechanisms of "aeolian" sediment transport which are mainly governed by wind direction and speed, and topographic conditions of the hinterland. Accordingly, higher concentrations of snow particles on sea-ice can be expected in areas where strong offshore winds erode sediment from exposed land surfaces or move sediment-laden snow off the coast line, while lower particle contents occur at sites of generally onshore winds or completely snow covered hinterland.

Preliminary quantitative investigations of the material under the binocular reveal mainly fine grained distributions of filtered snow sediments (Table 6). The portion of the coarse fraction mainly ranges between 10 and 30 areal% and does not exceed 40 % (mean: 28 %), while the silt fraction varies between 50 and 80 % (mean: 62 %). Most of the silt fraction generally consists of fine silt. The clay fraction is less abundant with values between 5 and 20 % (mean: 10 %).

Qualitative binocular investigations show that the coarse fraction of the sampled material partly consists entirely of fluffs, dust particles, plant debris and some clastic material. These types of "particles" were also detected at few stations in SPM samples of the upper water column and in filtered sea-ice sediments. However, most of the SPM filters, and particularly those of greater water depths (see above), were only insignificantly or not at all laden with fluffs and plant debris. Since all filtered samples were treated in the same way we can rule out a man-made pollution due to unclean sampling procedure and/or laboratory conditions. The fluffs, dust particles and especially the plant debris thus may be of atmospheric origin and indicative of aeolian entrainment of particles into snow and ice.

The clastic material in snow sediments consists mainly of angular to subangular quartz and feldspar with quantities varying between 30 and 80 % (mean: 55 %). Well rounded spherical quartz, feldspar and other particles are infrequent or not abundant. If rounded particles are present, they show mainly subprismoidal, sub- to wellrounded grain shapes. Dark minerals occur as generally slightly enhanced traces or in quantities of as much as 5 %. Rock fragments, mica and clay minerals occur only in traces. Irregularly shaped ash particles from waste- or coal combustion occur also in traces or low percentages, while spherical fly ashes were not abundant in snow sediments.

3.4 Radionuclides

According to recent studies (e.g. Joint Norwegian-Russian Expert Group 1996), most of the radioactive material - such as reactors of submarines, barkes filled with liquid and solid nuclear waste, and containers - dumped by the former Soviet Union in the Arctic were disposed in the fjords along the eastern coast of Novaya Zemlya at water depths ranging between 10 and 40 m. One purpose of the expedition was to investigate if potentially radioactively contaminated shelf surface deposits could be entrained into newly forming ice at extremely shallow sites (< 50 m water depth) in the western Kara Sea.

Unfortunately, we did not get the permission from the Russian Ministries to conduct our planned process studies along the eastern coast of Novaya Zemlya in the vicinity of - or directly in - the nuclear dumping sites. Thus, the KaBaEx field study was carried out as a "substitute" in the SW Kara Sea where we found comparable bathymetric, oceanographical and sedimentological conditions to what we can expect for the eastern coast of Novaya Zemlya and the dumping bays.

Results

According to our analyses, ^{137}Cs contamination of surface deposits along the eastern coast of Novaya Zemlya is relatively low compared to the Baltic- and Irish Seas (5-15 Bq/kg vs several 100 to 1000 Bq/kg). However, ^{137}Cs and ^{60}Co concentrations are enhanced inside the bays with highest contamination inventories, amounting to as much as 100,000 Bq/kg sediment in close vicinity to dumped containers (Joint Norwegian-Russian Expert Group 1996, Dethleff et al. 1997a). The surface deposits of the three main dumping bays along the coast of Novaya Zemlya are composed of extremely fine grained material with as much as 99 weight% <63µm. From todays knowledge about the entrainment of fine grained surface deposits into new ice along the Siberian coast we can assume that the potentially contaminated bottom material in the Novaya Zemlya fjords is predestinated for resuspension and incorporation into newly forming ice.

The water samples taken at station 1, 4 and 6 (Table 7) showed ^{137}Cs activities between 4.9 and 5.3 Bq/m^3, while the concentrations of ^{134}Cs were below detection limit of about 0.4 Bq/m^3. The determined activities were slightly above the expected "background" concentrations in the northern hemisphere, which still originates from the global atmospheric fallout of the weapon tests performed during the sixties. On contrary, the radioactive contamination of the North Sea, the North Atlantic Ocean, and the Barents and Kara Seas through discharge from the reprocessing plants at Sellafield (UK) and La Hague (France) decreased significantly during the past years (Kershaw et al. 1997). This shows that the weapon test fall-out still provides a stronger radioactive signal in the area of investigation as compared to the recent discharges of the North European reprocessing plants.

The KaBaEx surface sediment samples (Table 7) contained ^{137}Cs activities between 0.3 and 20 Bq/kg dry weight. Concentrations of ^{134}Cs, ^{60}Co and ^{241}Am were below detection limit. The slightly enhanced ^{137}Cs contaminations must be regarded as remnants from formerly stronger polluted Sellafield discharges. Thus, the transport of radioactivity from the Irish Sea to the Arctic Ocean is still documented in recent Kara Sea surface deposits, but cannot be traced in the modern water column (see above). The sediment activities of ^{137}Cs fall in the same range as those detected in surface deposits sampled in 1993 and 1994 in the central Kara Sea. These samples revealed ^{137}Cs activities between detection limit and 22.1

Bq/kg. A possible release and transport of radioactivity from the Novaya Zemlya dumping sites towards the SW Kara Sea could not be traced in the KaBaEx samples.

4. Discussion

Arctic sea-ice widely contains fine grained sediments either incorporated as layers and diffusively distributed clouds or enriched in surficial patches after one or several melting cycles. The geological and ecological importance of sediment inclusions in Arctic sea-ice has been demonstrated in various studies (e.g. Reimnitz et al. 1992, Nürnberg et al. 1994, Weeks 1994, Pfirman et al. 1997b, Landa et al. accepted). Sedimentological characteristics - such as extremely high silt and clay percentages - of sea-ice inclusions from various Arctic regions point to similar or identical entrainment processes active on the circumpolar shelf shallows during initial ice formation.

According to different authors (e.g. Reimnitz & Bruder 1972, Osterkamp & Gosink 1984, Reimnitz et al. 1992, 1993a, Dethleff et al. 1994), the following main mechanisms of turbid-ice formation can be pointed out:
(i) "suspension freezing": scavenging of fine grained (re)suspended particulate matter from the water column through buoyant rising frazil ice crystals, and entrainment of sediment by upward floating material-laden anchor ice (generally regarded as the most effective mechanism among all proposed),
(ii) enrichment of (re)suspended particulate matter by filtration in surface grease-ice streaks through convergent oceanic vortices, and
(iii) discharge of particle-rich river- or ocean water over near-coastal ice canopies (this was also observed at KaBaEx station 8 during sediment trap deployment and recovery).

4.1 Sea-ice sediment-entrainment in the Amderma/Vaygach flaw lead

After Reimnitz et al. (1993a, b), the entrainment of shelf surface deposits into newly forming ice through suspension freezing occurs under turbulent conditions at extremely shallow sites of <50 m water depth (Fig. 11). According to our oceanographic and sedimentological data obtained in the Amderma/Vaygach region, at least during field work period (and probably through the entire winter) both the local flaw lead and the under-ice water column were well mixed down to the bottom or the minimum to a depth of 30 m. This led to the design of the following entrainment scenario.

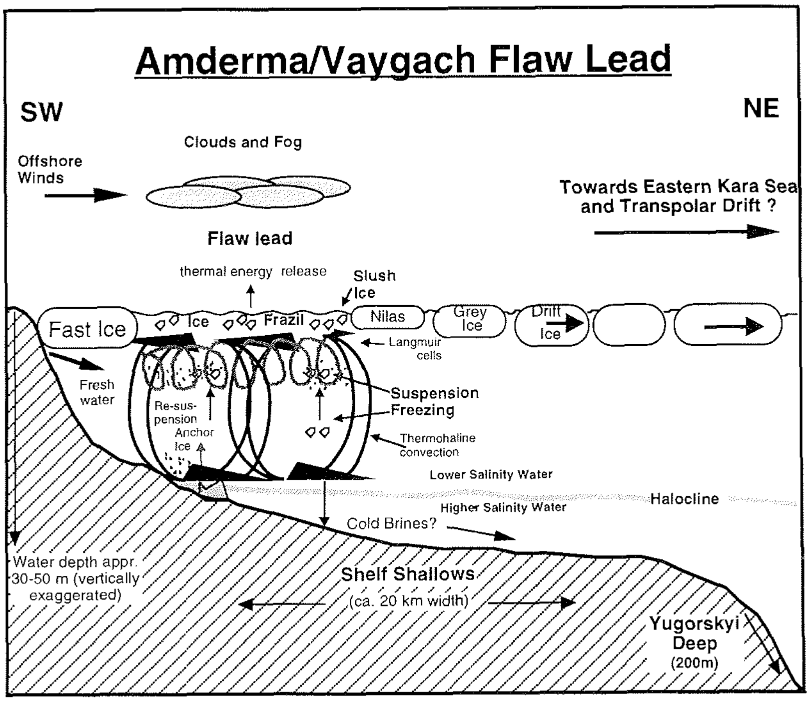

Fig. 11: Exemplary cross section of the Amderma/Vaygach flaw lead displaying possible hydrodynamic processes of turbid ice formation.

Turbulent oceanographic-sedimentological processes

Besides tidal currents and wind induced wave action, Langmuir circulation and thermohaline convection must be regarded as the main hydrodynamic processes responsible for oceanic mixing and resuspension of shelf surface deposits, and their subsequent entrainment into newly forming lead ice (Fig. 12). In contrast to the coastward fast ice, the enhanced material loads in the uppermost 60-70 core cm of the compressed drift ice close to or in the Amderma/Vaygach flaw lead points to intensified entrainment of (re)suspended material through the processes of suspension freezing and filtration into congealing frazil during the initial phase of ice formation over open water.

The shelf surface deposits in the area of investigation provide a large reservoir for the entrainment of particulate matter into newly forming ice. Strong evidence for a substantial contribution of local surface deposits to ice incorporated material is due to well comparing sedimentological characteristics of both environments when we consider the known processes of sediment entrainment into sea-ice deduced from former field work and laboratory studies.

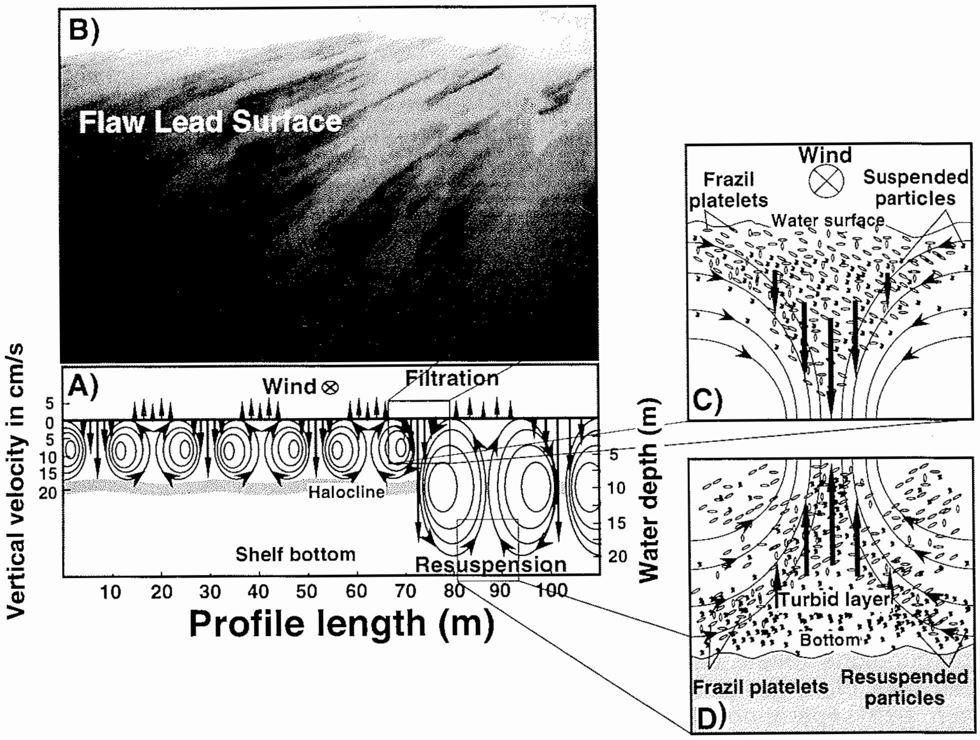

Fig. 12: Helical vortices in the water column (A) collect frazil ice in surface streaks (B) thereby enhancing the filtration and enrichment (C) of resuspended, fine grained surface deposits (D). The turbulent water masses may be forced through the wedge-like surface streaks of frazil and the fine grained SPM can be trapped in the slush ice cover in areas of downward motion. The collection efficiency of filtration and scavenging (enrichment) processes in western Arctic shelf areas were numerically approached and discussed e.g. by Osterkamp & Gosink (1984).

Higher abundances of sub- to well rounded, coarse-grained clastic material (mainly quartz) of 100-250 µm diameter was detected in southwestern Kara shelf surface deposits and in the water column. Abundances of rounded coarse clasts in the water column varied from station to station, but tended to decrease from the surface towards the near-bottom nepheloid layer (see section 3.2.2). On contrary, rounded, coarse-grained clastics were less abundant or practically absent in local sea-ice sediments (compare Fig. 8), which consisted mainly of angular silt. Irregularly shaped silt was also abundant in the shelf surface deposits, however, in lower concentrations as compared to sea-ice sediments.

This led to the assumption that hydrodynamic processes preferably activate and entrain fine grained, angular, clastic particles from the shelf surface or the nepheloid layer, thereby scavenging the angular silt matrix in bottom deposits and suspension load, and, simultaneously, enriching this grain spectrum in the newly forming ice cover. Sharma (1974) reported of turbid ice in the Bering Sea and also noted that the sediment composition in the ice was finer than that of the underlying shelf surface deposits.

Our findings are corroborated by suspended particle tank experiments carried out by Reimnitz et al. (1993b). Despite being available in the tank water column, coarse grains were generally less entrained into the forming slush ice cover or even released from rising frazil ice crystals for two reasons: i) particles trapped on the surface of frazil flocs led to unbalancing and subsequent tilting of the crystals, and ii) the coarse particles rolled from the crystal surfaces after turbulent agitation of the tank water column (which can be compared to wave or vortice agitation in nature). On contrary, due to their irrigular shape, coarse grained live plankton, diatoms and foraminifers, and particularly silt-sized clastic particles were entrained in significantly higher concentrations into the forming slush ice cover through rising frazil.

In short, turbulent hydrodynamic processes seem to be responsible for the entrainment and enrichment of sediment into newly forming sea-ice. Sea-ice incorporations reveal an extremely fine grained composition with a clay fraction even finer than that of deep sea sediments. This was observed during Atterberg grain size separation of Kara and Barents shelf sediments as well as sea-ice entrained material and deep sea deposits from the central Arctic Ocean.

Aeolian and riverine contribution

According to our data, a limited atmospheric contribution of non-clastic material (fluffs etc.) to the coarse fraction of sea-ice sediments in the Amderma/Vaygach region can be postulated. A minor aeolian contribution of clastic material is generally restricted to the (fine) silt fraction, but may also occur in the coarse fraction (#4). Aeolian entrainment of coarse clastics may be due to snow drift, and wind induced rolling and saltation of particles from the land surface towards the ice. Dethleff et al. (1993) reported sand to pebble sized rock material on the Lena river ice cover, which was propelled by the wind across the slick surface. In general, however, a significant contribution of saltated terrestrial clasts to sea-ice sediments can be ruled out due to continuous - and protecting - snow coverage on the land surface during the period of ice formation.

Riverine input to the hydro-cryo-sedimentological regime in the Amderma/Vaygach area seems to be also of minor importance since no large rivers discharge into that part of the Kara Sea (compare Fig. 3). Additionally, relatively low percentages of well rounded clastic material - implying a long range fluvial transport - are abundant in local shelf surface deposits. Most of the material, that may be provided by coastal retreat through thermal abrasion and/or mechanical erosion during the short summer period, will be transported along shore towards the east. This can be inferred from active sand bars at the northwestern Kara river mouth (Karskaya Bay), and from eastward extended barrier islands (Torasavey, Levdiev) parallel to the southern coast of the Baidaratskaya Bay. Conclusively, only little contribution of atmospheric, riverine and fluvial material to local sea-ice sediments can be expected in the southwestern Kara Sea.

4.2 Quantification, transport and pathways of SW Kara Sea ice-sediments

The mechanisms described above afford the entrainment of considerable amounts of sediment into newly forming sea-ice. Minimum concentrations of sediment in Arctic sea-ice amount to 800-3000 t/km^2 (Barnes et al. 1982, Osterkamp & Gosink 1984), while maximum concentrations were reported to reach as much as 90,000 t/km^2 (Gilbert 1983, McCann & Dale 1986). For example, annualy between 4 and 11 mio t of sediment can be exported from the Laptev Sea through sea-ice transport i) from winter flaw leads, and ii) after entrainment during fall freeze-up on extended areas of the shelf (Dethleff 1995b, Eicken et al. 1997). The entrained material contributes considerably to the sediment budget of the Siberian Branch of the Transpolar Drift Ice System. After Wollenburg (1993) and Larssen et al. (1987), annualy between 7 and 150 mio t of ice-incorporated clastic material may leave the Arctic Ocean through the Fram Strait towards the North Atlantic.

According to sedimentological investigations supported by foreward and backward trajectory model results derived from drift buoy tracks, atmospheric pressure data and ocean current velocities (Pfirman et al. 1997b, Dethleff et al. 1997b), considerable portions of the sea-ice sediments sampled in the eastern central Arctic and in Fram Strait (e.g. Nürnberg et al. 1994, Dethleff 1997) may have been entrained in the Laptev Sea, and the eastern and north western Kara Sea. After being transported into Fram Strait and the Norwegian-Greenland Sea, the material will be released and thus can substantially contribute to the regional annual deep-sea sedimentation.

On contrast to the Laptev Sea, comparatively little is known about the origin and pathways of turbid sea-ice formed on the Kara Sea shelf and, particularly produced in near-coastal flaw leads. To estimate the possible ranges of entrainment and transport/export rates of sediment through sea-ice from the Amderma/Vaygach flaw lead towards the central Kara Sea and the Arctic Mediterranean, we combined local lead-ice accumulation rates deduced from Martin & Cavalieri (1989) with our sea-ice sediment data and recent ice-drift modeling results.

First, we assumed the 4-year mean areal extent and ice formation rates of the east Novaya Zemlya flaw lead sections A-C (Fig. 4, Table 8) from Martin & Cavalieri (1989) to be representative for the 1996/97 winter season. Based on satellite images

(Fig. 4) and the general atmospheric winter conditions (Martin & Cavalieri 1989) we then estimated that the lead section D (Amderma/Vaygach lead) has approximately the same areal extent and ice production rates as section A. Since at maximum the upper 60-70 cm of an ice sheet might have been formed in a lead area under turbulent conditions (Zakharov 1966), we only considered the material load incorporated in the uppermost core-sections (Fig. 10) for the following sediment entrainment and export budgets. The resulting mean value of 11 mg/l ($\approx$11 g/m^3$\approx$11x10^3 t/km^3) was then combined with the ice volume assumed for the Amderma/Vaygach lead (Table 8).

Our results show that the Amderma/Vaygach lead area D *entrains* roughly 80,000 t of sediment into new ice during the 1996/97 winter season. The *export rates* of lead section D have to be significantly reduced as compared to the *entrainment rates* since - according to both forward ice trajectory simulations (Dethleff et al. 1997b; see also Fig. 4) and numerical model estimates (I. Rigor, 1997, pers. comm.) - the lead-ice formed in this area leaves the Kara Sea only with a probability of at maximum 10 % before summer melt. By far the most of the ice produced in the Amderma/Vaygach lead will melt during the following summer thereby releasing the sediment load to the central Kara shelf. Farther to the north along the east coast of Novaya Zemlya and in the eastern Kara Sea, the probability of turbid-ice export from near-coastal leads towards the central Arctic Ocean approximates 100%.

In order to estimate the ^{137}Cs export through sea-ice entrained sediments from the Amderma/Vaygach lead we combined the above sediment entrainment and export calculations with detected minimum and maximum radioactive contamination levels in surface deposits close to - or directly beyond - the flaw lead sections (Table 9). *Entrained* and *exported* rates of ^{137}Cs differ significantly depending on i) the contamination level in the sediment source on the shelf surface, and ii) the local ice drift conditions. The minimum and maximum export rates of ^{137}Cs are not expected to exceed 0.025 and 1.5 GBq, respectively. This is very little compared to the estimated total Kara Sea ^{137}Cs inventory of as much as 1 PBq. Furthermore, we have to consider in this context that the type of entrainment mechanism also influences the level of sediment-bond ^{137}Cs in sea-ice. While sediment entrained through anchor ice directly floats upward into the congealing new-ice cover, resuspended surface deposits, which are lifted up by rising frazil, get into contact with the surrounding water masses and release most ($\approx$99 %) of the ^{137}Cs concentration through dissolution. Assuming that both frazil scavenging and anchor ice formation contribute 50 % to the entrainment of sediments into the Amderma/Vaygach lead-ice, we have to reduce the total ^{137}Cs entrainment and export rates in Table 9 by factor 2.

5. Conclusions

The most important results of the KaBaEx '97 expedition are summarized as follows:

1) Near coastal flaw leads occur in the southwestern Kara Sea over extremely shallow water depths ranging from 10 to 15 m. The fast ice edge is often stabilized by grounded pressure ridges (stamukhi) formed through onshore pressing ice. This is an essential difference to what we have learned from the Laptev Sea and is rather comparable to the ice situation in the Alaskan Arctic (see Reimnitz et al. 1994).

2) During our field work only first-year ice was observed and sampled indicating that this area of the Kara Sea was ice free during the previous late summer.

3) (Re)suspended particulate matter - and particularly coarse clasts - partly revealed enhanced abundances in the upper water column. This points to a well mixed water column under the ice cover and in the Amderma/Vaygach flaw lead. This was supported by the evaluation of the CTD profiles.

4) The ice produced in the Amderma/Vaygach flaw lead was more turbid than the fast ice attached to the coast. We believe that turbulent processes of turbid ice formation are very effective in this shallow area during winter. Preferably fine grained material is incorporated into the newly forming ice, despite the shelf surface deposits consist mainly of sandy material. Fall freeze-up must also be regarded as an effective entrainment period.

5) Coarse grained, well rounded clasts were mainly found in shelf surface deposits and in the water column, while such particles were less abundant or even absent in the overlying sea-ice cover. This supports results from different studies (e.g. Reimnitz et al. 1993b) documenting that sand-sized, rounded clasts are generally less entrained from the water column into Arctic sea-ice than silt particles, and that the underlying shelf deposits tend to be coarser than local sea-ice sediments.

6) Furthermore, we postulate the scavenging of fine grained clasts from the bottom deposits through vortical resuspension and sea-ice entrainment. The fine grained material is lifted upward and enriched in the newly forming ice cover.

7) Aeolian and riverine transport from land to sea must be ruled out as important factor for the occurrence of (fine) particulate matter in SW Kara Sea ice.

8) Roughly 80,000 t of sediment were entrained into the Amderma/Vaygach lead ice during the 1996/97 winter season. Due to unfavorable ice drift conditions, only 10 % of the sediment may leave that part of the Kara Sea towards the central Arctic Ocean, while most of the material will be released on the Kara shelf during summer melt.

9) ^{137}Cs pollution levels of local shelf surface deposits are low compared to the Irish Sea, the English Channel and the Baltic Sea. The amounts of sediment-bond ^{137}Cs entrained into the Amderma/Vaygach lead-ice and exported from that area are also low considering the total man-made Kara Sea radionuclide-inventory.

6. Acknowledgements

We are indebted to all MMBI colleagues, particularly to Prof. Dr. Matishov, Dr. Denisov, and Dr. Dimitri Matishov, who were decisively involved in the preparation and conductance of the KaBaEx '97 expedition. Dr. G. Tarasov and Andrej Kondakov earned our highest respect for their great logistic preparation and field guidance and we especially thank Pavel (?) and Vilori Chasankayev for their kind technical and scientific support during the ice works. Furthermore, we appreciated the great hospitality and the cultural frankness of the people in Amderma, and we are very grateful to Andrej Anatoliwitsch, the chief of the local Hydrometeorological Station, for his open scientific discussion. The helicopter crew earned our highest respect during the ice works. The project was funded by the "Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit". The scientific content of this report does not necessarily reflect the opinion of the "Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit". We gratefully thank Carsten Esch for his substantial help providing radio, telephone and e-mail contact between the expedition crew and the home institutions. We gratefully thank Ortrud Runze for spell checking of this report.

7. References

Barnes, P., Reimnitz, E. & Fox, D.H. (1982): Ice rafting of fine grained sediment, a sorting and transport mechanism, Beaufort Sea, Alaska. - J. Sed. Petr., 52, 2, pp. 493-502.

Barnett, D. (1991): Sea ice distribution in the Soviet Arctic. - In: Brigham, L. A. (ed.), The Soviet Maritime Arctic, London, Belhaven Press, pp. 47-62.

Buernkov V.I. & Vasil'kov, A.P. (1995): The influence of runoff from the land on the distribution of hydrologic characteristics of the Kara Sea. - Oceanology, 34, 5, pp. 591-599.

Buzov, A.Y. (1991): Natural factors and their influence on transit sailing on the Northern Sea Route, Part I, The Northern Sea Route project - pilot studies report. - Fridtjof Nansen Institute, Oslo.

Churun, V.N. & Timokhov, L.A. (1995): Cold bottom water in the southern Laptev Sea. In: H. Kassens, D. Piepenburg, J. Thiede, L. Timokhov, H. W. Hubberten & S. Priamikov (eds.): Russian-German Cooperation: Laptev Sea System. - Reports on Polar Research, 176, pp. 107-113.

Darby, D.A., Burckle, L.H. & Clark, D.L. (1974): Airborne dust on the Arctic pack ice, its composition and fallout rate. - Earth Planet. Sci. Lett., 24, pp. 166-172.

Dethleff, D., Nürnberg, D., Reimnitz, E., Saarso, M. & Savchenko, Y.P. (1993): East Siberian Arctic Region Expedition '92: The Laptev Sea - Its significance for Arctic sea-ice formation and transpolar sediment flux. - Reports on Polar Research, 120, pp. 44.

Dethleff, D., Kleine, E. & Loewe, P. (1994): Oceanic heat loss, sea ice formation and sediment dynamics in a turbulent Siberian flaw lead. In: Proceedings of the summer school of Physics of ice-covered seas, Savonlinna, Finland. - Report Series in Geophysics No. 28, pp. 35-40, University of Helsinki, Dept. of Geophysics.

Dethleff, D. (1995a): Die Laptev See - eine Schlüsselregion für den Fremdstoffeintrag in das arktische Meereeis. - Diss. Christian-Albrechts-Universität zu Kiel, Kiel, Germany, pp. 1-111.

Dethleff, D. (1995b): Sea ice and sediment export from the Laptev Sea flaw lead during 1991/92 winter season. - In: H. Kassens, D. Piepenburg, J. Thiede, L. Timokhov, H. W. Hubberten & S. Priamikov (eds.): Russian-German Cooperation: Laptev Sea System. - Reports on Polar Research, 176, pp. 78-93.

Dethleff, D. & Reimnitz, E. (1996): Remote sensing of flaw feads in the eastem Arctic - With a special emphasis on the Siberian Laptev Sea. - Fourth Circumpolar Symposium on Remote Sensing of the Polar Environment, 29 April - 1 May 1996, Lyngby, Denmark.

Dethleff, D. (1997): Sea-Ice Sediments. - in: R. Stein & K. Fahl (eds.). Scientific Cruise Report of the Arctic Expedition ARK-XIII/2 of RV "Polarstern" in 1997. - Reports on Polar Research, 255, pp. 90-96.

Dethleff, D., Nies, H., Harms, I.H., Karcher, M.J. & Strand, P. (1997a): Sea-ice as transport agent for potentially radioactively contaminated sediment from Kara Sea dumping sites to the North Atlantic. - The Third International Conference on Environmental Radioactivity in the Arctic, Extended Abstracts, vol. 2, pp. 197-199, Tromsö, Norway, 1-5 June 1997.

Dethleff, D., Kuhlmann, G., Nürnberg, D., Harms, I.H., Karcher, M.J., Nies, H., Rigor, I. & Shipboard Scientific Party RV Polarstern ARKXIII/2 (1997b): Drift of Sediment-Laden Arctic Sea Ice - Preliminary Results from 1997 ARKXIII/2 RV "Polarstern" Cruise and Numerical Model Studies. EOS, Transactions, AGU vol. 78, 46, pp. 346.

Eicken, H., (1992): Salinity profiles of Antarctic sea ice: Field data and model results. - J. Geophys. Res., 97, C10, pp. 15.545-15.557.

Eicken, H., Reimnitz, E., Alexandrov, V., Martin, T., Kassens, H. & Viehoff, T. (1997): Sea-ice processes in the Laptev Sea and their importance for sediment export. - Cont. Shelf. Res., 17, 2, pp. 205-233.

Geogruppen AS (1994): Barents Sea and Kara Sea - Holocene sediment thicknesses, surface sediment distribution. - Report no. 93024.02, GeoGruppen as, Strandtorget 2B, 9008 Tromsö, Norway.

Gilbert, R. (1983): Sedimentary processes of Canadian Arctic fjords. - Sed. Geol., 36, pp. 147-175.

Groves, J.E. & Stringer, W.J. (1991): The use of AVHRR thermal infrared imagery to determine sea ice thickness within the Chukchi polynya. Arctic, 44, pp. 130-139.

Harms, I.H. (1997): Freshwater runoff and ice formation in Arctic Shelf Seas - Results from a high resolution Kara Sea Model. - Extended abstract. in: Proceedings of the WCRP/ACSYS Conference on Polar Processes and Global Climate, Rosario Resort, Orcas Island, Washington, USA, 3-6 November 1997. International ACSYS-Office, Oslo, Norway.

Johnson, D., McClimans, T.A., King, S. & Grennes, Ø. (1997): Fresh water masses in the Kara Sea during summer. - J. Mar. Systems, 12, pp. 127-145.

Joint Norwegian-Russian Expert Group (1996): Dumping of radioactive waste and investigation of radioactive contamination in the Kara Sea. - Norwegian Radiation Protection Authority, pp. 1-55.

Kempema, E.W., Reimnitz, E. & Barnes, P. (1989): Sea ice sediment entrainment and rafting in the Arctic. - J. Sed. Petr., 59, 2, pp. 308-317.

Kershaw, P., Gurbutt, P., Woodhead, D., Leonhard, K. & Rees, J. (1997): Estimates of ^{137}Cs fluxes in Northern waters from recent measurements. - Sc. Tot. Envir., 202, pp. 211-222.

King, S., Carroll, J., Krosshavn, M., Johnson, D.R., Phillips, G.W., August, R.A., Boisson, F. & Teyssie, J.L. (1997): Transport of Cs in the Kara Sea -

Radioprotection-Colloques, Volume 32, C2, special issue: 'Radionuclides in the Oceans (RADOC 96-97), Part I: Inventories, behaviour and processes, 7 - 11 October 1996, Cherbourg - Octeville, France.

Landa, E., Reimnitz, E., Beals, D., Pochkowski, J. & Rigor, I. (accepted for Arctic): Transport of ^{137}Cs and $^{239,240}Pu$ by ice rafted debris in the Arctic Ocean.

Larssen, B.B., Elverhøi, A. & Aagaard, P. (1987): Study of particulate material in sea ice in the Fram Strait - a contribution to paleoclimate research. - Polar Res., 5, 3, pp. 313-315.

McCann, S.B. & Dale, J.E. (1986): Sea ice breakup and tidal flat processes, Frobisher Bay, Baffin Island. - Phys. Geogr., 7, pp. 168-180.

Martin, S. & Cavalieri, D.J. (1989): Contributions of the Siberian shelf polynyas to the Arctic Ocean intermediate and deep water. - J. Geophys. Res., 94, C9, pp. 12,725-12,738.

Mullen, R.E., Darby, D.A. & Clark, D.L. (1972): Significance of atmospheric dust and ice rafting for Arctic Ocean sediment. - Geol. Soc. Am. Bull., 83, 1, pp. 205-211.

NAVY/NOAA Joint Ice Center (1975-1993): Eastern-Western Arctic sea ice analysis. - Naval Polar Oceanographic Center, Suitland, MD, USA.

Nies, H., Harms, I.H., Karcher, M.J., Dethleff, D., Bahe, C., Kleine, E., Loewe, P., Oberhuber, J.M., Kuhlmann, G., Matishov, D., Stepanov, A. & Vasiliev, O.F. (in prep. for subm. to DHZ): Anthropogenic radioactivity in the Arctic Ocean - Results of a joint project.

Nürnberg, D., Wollenburg, I., Dethleff, D., Eicken, H., Kassens, H., Letzig, T., Reimnitz, E. & Thiede, J. (1994): Sediments in Arctic sea ice - entrainment, transport and release. - Mar. Geol., 119, pp. 185-214.

Nürnberg, D., Levitan, M.A., Pavlidis, J.A. & Shelekova, E.S. (1995): Distribution of clay minerals in surface sediments from the eastern Barents and south-western Kara Seas. - Geol. Rundsch., 84, 665-682.

Osterkamp, T.E. & Gosink, J.P. (1984): Observations and analysis of sediment laden sea ice. - In: P. W. Barnes, D. M. Schell & E. Reimnitz (eds.), The Alaska Beaufort Sea: Ecosystem and Environment: San Francisco, Academic Press, p. 73-94.

Pavlov, V. K., Timokhov, L.A., Baskakov, G.A., Kulakov, M.Yu., Kurazhov, V.K., Pavlov, P.V., Pivovarov, S.V. & Stanovoy, V.V. (1994): Hydrometeorological regime of the Kara, Laptev, and East Siberian Seas. Part 1: Processes of transfer and transformation of contaminants inflowing by continental discharge into the Kara, Laptev and East Siberian Seas. Federal Service of Russia for hydrometeorology and monitoring of the environment - The Arctic and Antarctic Research Institute, pp. 1-179.

Pavlov, V.K. & Pfirman, S.L. (1995): Hydrographic structure and variability of the Kara Sea: Implications for pollutant distribution. - Deep-Sea Res., 42, 6, pp. 1369-1390.

Pfirman, S.L., Lange, M.A., Wollenburg I. & Schlosser, P. (1990): Sea ice characteristics and the role of sediment inclusions in deep-sea deposition. - In: U. Bleil & J. Thiede (eds.), Arctic versus Antarctic - Geological History of the Polar Oceans, NATO ASI Series, Dordrecht, Kluwer, C308, pp. 187-211.

Pfirman, S.L., Kögeler, J.W. & Rigor, I. (1997a): Potential for rapid transport of contaminants from the Kara Sea. - Sc. Tot. Envir., 202, pp. 111-122.

Pfirman, S.L., Colony, R., Nürnberg, D., Eicken, H. & Rigor, I. (1997b): Reconstructing the origin and trajectory of drifting Arctic sea ice. - J. Geophys. Res., 102, C6, pp.12,575-12,586.

Reimnitz, E. & Bruder, K.F. (1972): River discharge into an ice-covered ocean and related sediment dispersal, Beaufort Sea, coast of Alaska. - Geol. Soc. Am. Bull, 83, pp. 861-866.

Reimnitz, E., Marincovich jr., L., McCormick, M. & Briggs, W.M. (1992) Suspension freezing of bottom sediment and biota in the Northwest Passage and implications for Arctic Ocean sedimentation. - Can. J. Earth Sci., 29, pp. 693-703.

Reimnitz, E., McCormick, M., McDougall, K. & Brouwers, E. (1993a): Sediment-export by ice rafting from a costal polynya, Arctic Alaska. - Arctic Alp. Res., 25, 2, pp. 83-98.

Reimnitz, E., Clayton, J.R., Kempema, E.W., Payne J.R. & Weber, E. (1993b): Interaction of rising frazil with suspended particles: tank experiments with applications to nature. - Cold Reg. Sci. Technol., 21, pp. 117-135.

Reimnitz, E., Dethleff, D. & Nürnberg, D. (1994): Contrasts in Arctic shelf sea-ice regimes and some implications: Beaufort Sea versus Laptev Sea. - Mar. Geol., 119, pp. 215-225.

Schwarz, J. (1994): Der nördliche Seeweg, HSVA-Bericht Nr. E 243/94, FE-Kennzeichen 40298/92, The Hamburg ship model basin. - Hamburg, Germany, pp. 1-90.

Sharma, G.D. (1974): Contemporary depositional environment of the eastern Bering Sea. - in: D.W. Hood & E.J. Kelly (eds.). Oceanography of the Bering Sea: Fairbanks, Univ. Alaska, 517-537.

Weeks, W. (1994): Possible roles of sea ice in the transport of hazardous material. - Arct. Res. U. S., vol. 8, pp. 34-52.

Wollenburg, I. (1993): Sedimenttransport durch das arktische Meereis: Die rezente lithogene und biogene Materialfracht. - Berichte zur Polarforschung (Rep. Pol. Res.), 127, pp. 1-159.

Zakharov, V.F. (1966): The role of flaw leads off the edge of fast ice in the hydrological and ice regime of the Laptev Sea. - Academy of Sciences of the USSR, Oceanology, No. 6, pp. 815-821.

8. Annex

Table 1: Station list.

Station #	date	Latitude	Longitude	Water depth (m)	Type of samples	Wind speed (m/s)	Wind dir. (°)	Cloud coverage (%)	T air (°C)	Snow thickness (cm)	Ice type	Ice relief	Ice thickness (cm)	Floe size (m)	ca. Water salin.	ca. Water temp. (°C)
1	13.4.	69°45.59'N	61°36.38'E	6	snow, ice, water sediment, CTD	8	240	100	-11.0	5-10	fast	level	70	-	34.1	-1.9
2	14.4.	69°47.18'N	61°36.46E	21	snow, ice, sedim., CTD	7	240	80	-11.5	-	fast	rubble, ridges	130	-	34.5	-1.85
3	15.4.	69°47.13'N	61°40.17E	18	snow, ice, sedim.	4-5	220	0	-4.0	7-15	fast	level	170	-	-	-
4	16.4.	69°44.10'N	62°42.37E	11	snow, ice, water sediment, CTD	0-1; 4-5	220	70	-	10	fixed drift	level, rubble	127	400	34	-1.84
5	16.4.	69°46.01'N	62°23.07E	21	snow, ice, water sediment, CTD	5-6	220	60	+7.0	15-20	drift	level, rubble	89	300	34	-1.9
6	17.4.	69°53.42'N	60°38.59'E	41.5	snow, ice, water sediment, CTD	8-10	180	10	+3.6	10-15	drift	level, rubble	68	500	34.5	-1.82
7	17.4.	69°51.53'N	61°33.06'E	40	snow, ice, water sediment, CTD	11	180	10	+3.6	10	drift	level, rubble	75	500	34.5	-1.78
8	20.4.	69°46.48'N	61°40.57'"	13	water, sediment, CTD, sed. trap	6-7	320	100	-	5	fast	level-ridges	-	-	34.5	-1.70

Table 2: List of sampled material.

Station	Sample material	Sampling intervall/depth
1	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	4 m
	grease ice	from borehole
	ice core (filtered)	0-15 cm
	(entrained sediments)	15-31 cm
		31-45 cm
		45-60 cm
		60-75 cm
		75-90 cm
	ice ridge	no
	(entrained sediments)	
	snow	yes
2	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	10 m
	grease ice	no
	ice core (filtered)	0-12 cm
	(entrained sediments)	12-23 cm
		23-45 cm
		45-65 cm
		65-80 cm
		80-97 cm
		97-117 cm
		117-130 cm
	ice ridge	yes
	(entrained sediments)	
	snow	yes
3	surface sediment	0-0.5 cm
		0-3 cm
	water column	2 m
	(suspended particulate matter)	11 m
		18 m
	grease ice	no
	ice core (filtered)	0-12 cm
	(entrained sediments)	12-27 cm
		27-40 cm
		40-57 cm
		57-72 cm
		72-86 cm
		86-100 cm
		100-114 cm
		114-128 cm
		128-142 cm
		142-156 cm
		156-170 cm
	ice ridge	no
	(entrained sediments)	
	snow	yes
4	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	5 m
		9 m
	grease ice	no
	ice core (filtered)	0-12 cm
		12-24 cm
		24-36 cm
	38-45 and 50-52 cm coll. sed.	36-52 cm
	63-66 cm coll. sed.	52-68 cm
		68-84 cm
		84-96 cm
		96-110 cm
	109-127 cm coll. sed.	110-127 cm
	ice ridge	yes
	(entrained sediments)	
	snow	yes

Station	Sample material	Sample Intervall
5	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	10 m
		20 m
	grease ice	no
	ice core	0-12 cm
	(entrained sediments)	12-22 cm
		22-39 cm
		39-59 cm
		59-75 cm
		75-89 cm
	ice ridge	yes
	(entrained sediments)	
	snow	no
6	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	20 m
		40 m
	grease ice	no
	ice core (filtered)	0-16
	(entrained sediments)	16-28 cm
		28-44 cm
		44-60 cm
		60-68 cm
	ice ridge	yes
	(entrained sediments)	
	snow	no
7	surface sediment	0-0.5 cm
		0-3 cm
	water column	1 m
	(suspended particulate matter)	20 m
		37 m
	grease ice	no
	ice core (filtered)	0-17 cm
	(entrained sediments)	17-28 cm
		28-44 cm
		44-60 cm
		60-73 cm
	ice ridge	yes
	(entrained sediments)	
	snow	no
8	surface sediment	0-0.5 cm
		0-3 cm
	water column	2 m
	(suspended particulate matter	7 m
	from sediment traps)	12 m
	grease ice	no
	ice core (filtered)	no
	(entrained sediments)	
	ice ridge	no
	(entrained sediments)	
	snow	no

Table 3: Smear slide analyses of bottom deposits and sea-ice sediments.

Grain Size (in %)						*Components* (in %)													
Station #	Sand %	Silt %	Clay %	Sediment type	Remarks	Station #	Quartz, Fsp. angular	Quartz, Fsp. subrounded	Quartz, Fsp. rounded	Rock fragments	Mica	Org.-clay-iron-aggr.	Clay Min.*	Opaque minerals	Heavy min.	Diatoms, spores etc.	Plant debris	Remarks
1	85	10	5	sand	sed.-surf	1	25	40	10	10	-	-	5	traces	traces	5	-	qz. subangular in coarse fraction
2	40	50	10	sandy silt	sed.-surf	2	20	45	5	5	-	-	10	5	traces	5	traces	green, well rounded minerals (Glaukonite)
2	5	30	65	silty clay	ice/ridge	2	35	5	-	-	-	25	15	traces	traces	15	traces	coarse fract. mainly biogen. + aggr. of clayey mat. + idiom. min
3	60	35	5	silty sand	sed.-surf	3	30	40	5	10	traces	-	5	traces	traces	5	-	varying minerals in silt-fraction
4	>85	10	<5	sand	sed.-surf	4	45	25	5	5	-	5	5	traces	traces	10	traces	many diatoms in silt fraction
4A	5	85	10	silt	ice/ridge	4A	65	10	-	-	5	5	5	5	traces	5	traces	coarse fract. mainly aggr.; silt fract.: coarse to middle silt
4B	10	75	15	silt	ice-core	4B	70	10	-	5	-	-	10	traces	traces	traces	traces	coarse fract. aggregrates
5	75	20	5	sand	sed.-surf	5	50	30	5	-	-	-	5	traces	-	traces	-	subr. to subangular quartz in coarse fract.
5	<5	40	55	silty clay	ice-core	5	70	5	-	-	5	traces	10	.5	traces	traces	-	15-20core cm; idiom. gypsum minerals, very fine grained material
6	45	35	20	silty sand	sed.-surf	6	55	20	-	traces	5	traces	5	traces	5	5	traces	biogenic material mainly spongae a. diatoms; fine to middle silt
6	15	70	15	cl.sand.silt	ice/ridge	6	65	10	-	5	5	traces	5	traces	traces	5	traces	more coarse silt in ice than in sed.-surf.
7	15	70	15	silt	sed.-surf	7	50	25	-	5	traces	5	5	traces	traces	5	traces	much fine silt
7	5	85	10	silt	ice/ridge	7	60	15	-	traces	traces	10	5	traces	traces	5	traces	coarse fract. mainly aggr. of fine grain. mat.; high abund. of fine silt
8	>85	10	<5	sand	sed.-surf	8	55	25	5	10	traces	-	traces	traces	traces	traces	-	quartz subangular to subrounded in coarse fraction

Table 4: Content of particulate matter in snow, ice and water column.

Station #	Ice core section (cm) or *sample*	Description	Salinity	Amount of filtered water (ml)	Particle content (mg/l)	Remarks
1	*snow*	-	-	1060	11.37	-
	0-15	no visible inclus.	-	2600	3.14	-
	15-31	no visible inclus.	-	3092	2.48	-
	31-45	no visible inclus.	-	2920	2.27	-
	45-60	no visible inclus.	-	2968	2.31	-
	60-75	no visible inclus.	-	2702	1.97	-
	75-90	brownish incl.	-	1141	5.50	only 40% filtered
	slush ice	from bore hole	31.6	1520	2.38	-
	SPM	1m water depth	-	10.200	0.55	-
	SPM	4m water depth	-	9640	1.72	-
2	*snow*	-	0.1	800	2.75	-
	0-12	no visible inclus.	7.7	764	3.23	-
	12-23	no visible inclus.	8.3	707	2.49	-
	23-45	no visible inclus.	6.7	1500	1.59	-
	45-65	no visible inclus.	4.2	1355	2.08	-
	65-80	no visible inclus.	4.0	910	2.15	-
	80-97	no visible inclus.	4.0	1180	2.31	-
	97-117	no visible inclus.	4.3	1350	8.49	-
	117-130	brownish incl.	7.5	868	20.5	-
	SPM	1m water depth	-	2800	1.67	-
	SPM	10m water depth	34.5	2000	5.82	-
3	*snow*	no visible inclus.	0.0	800	1.87	-
	0-12	no visible inclus.	4.5	240	4.45	sample loss
	12-27	no visible inclus.	0.8	382	6.27	sample loss
	27-40	no visible inclus.	4.2	618	7.72	sample loss
	40-57	no visible inclus.	2.7	942	3.00	sample loss
	57-72	no visible inclus.	5.4	1140	2.50	-
	72-86	no visible inclus.	6.6	998	3.27	-
	86-100	no visible inclus.	1.9	636	9.46	-
	100-114	no visible inclus.	-	-	-	total loss
	114-128	no visible inclus.	3.6	640	3.51	-
	128-142	no visible inclus.	4.6	910	1.61	-
	142-156	no visible inclus.	3.2	526	6.10	-
	156-170	brownish incl.	4.6	410	5.43	-
	SPM	2m water depth	33.1	1070	2.41	-
	SPM	11m water depth	33.2	1050	2.96	-
	SPM	18m water depth	33.3	1100	13.77	-
4	*snow*	no visible inclus.	0.0	810	4.18	-
	0-12	no visible inclus.	6.0	778	12.81	-
	12-24	visible inclusions	6.3	1010	32.65	-
	24-36	no visible inclus.	4.9	725	10.88	-
	36-52	visible inclusions	2.6	780	17.36	-
	52-68	visible inclusions	2.0	590	35.14	-
	68-84	no visible inclus.	2.6	888	9.77	-
	84-96	no visible inclus.	2.1	695	10.56	-
	96-110	no visible inclus.	3.1	908	21.59	-
	110-127	brownish incl.	-	-	-	total loss
	SPM	1m water depth	32.8	1060	4.16	-
	SPM	5m water depth	33.1	1050	2.00	-
	SPM	9m water depth	33.1	1050	1.87	-
5	0-12	no visible inclus.	6.1	360	9.33	-
	12-22	visible inclusions	2.2	145	137.35	sample loss
	22-39	no visible inclus.	4.4	539	4.47	sample loss
	39-59	no visible inclus.	2.9	980	2.29	-
	59-75	no visible inclus.	5.2	880	2.85	-
	75-89	brownish incl.	6.7	587	11.33	-
	SPM	1m water depth	32.8	1060	2.64	-
	SPM	10m water depth	32.8	1050	2.39	-
	SPM	20m water depth	33.0	1090	2.14	-

Station #	Core section (cm) or *sample*	Description	Salinity	Amount of filtered water (ml)	Particle content (mg/l)	Remarks
6	*snow*	no visible inclus.	0.0	1829	2.45	-
	0-16	no visible inclus.	5.3	1900	3.18	-
	16-28	no visible inclus.	5.0	1630	3.37	-
	28-44	no visible inclus.	4.5	2060	2.28	-
	44-60	no visible inclus.	4.0	2100	2.94	-
	60-68	brownish incl.	6.1	445	12.16	-
	SPM	1m water depth	33.2	1025	2.12	-
	SPM	20m water depth	33.2	1035	1.63	-
	SPM	40m water depth	33.7	1013	2.78	-
7	0-17	no visible inclus.	6.2	1968	6.92	-
	17-28	no visible inclus.	5.0	1303	6.60	-
	28-44	no visible inclus.	4.1	1950	2.17	-
	44-60	no visible inclus.	3.6	1978	4.69	-
	60-73	brownish incl.	6.2	1226	5.49	-
	SPM	1m water depth	33.2	935	3.59	-
	SPM	20m water depth	33.2	1000	4.23	-
	SPM	37m water depth	33.3	1040	1.89	-
8	*SPM*	2m water depth	32.0	282	38.33	Sed. trap 10h
	SPM	7m water depth	33.7	275	22.97	Sed. trap 10h
	SPM	12m water depth	33.2	280	23.30	Sed. trap 10h

SPM: suspended particulate matter
brownish incl.: microbiogenic activity, algae bloom

Table 5: Grain size distribution and sample composition of SPM.

Grain Size (in %)						***Components*** (in %)														
Station #	Water depth	Sand %	Silt %	Clay %	Sediment type	Station #	Quartz, Feldspar etc. angular	Quartz, Feldspar etc. subround.	Quartz, Feldspar etc. (well)round.	Fluffs	Rock fragments	Mica (flocs)	Combust. products	Clay Min.	Opaque minerals	Heavy min.	Micro-organisms	Plant debris	Fossil raisin	Remarks
1	1 m	25	65	10	silt	1	70	5	-	20	-	traces	traces	tr.	traces	traces	traces	traces	tr.	fluffs, fossil raisin (amber) and subangular to subrounded quartz in coarse fraction
	4 m	35	60	5	sandy silt	1	50	5	-	30	-	traces	5	tr.	traces	traces	traces	5	tr.	fluffs, fossil raisin and subangular to subrounded quartz in coarse fraction
2	1 m	10	70	20	silt	2	60	-	-	25	-	traces	10	tr.	traces	traces	traces	traces	tr.	extremely fine silt; enhanced abundances of silver discolored combustion flocs (inorganic)
	10 m	25	70	5	silt	2	60	-	-	5	-	30	traces	tr.	traces	traces	traces	traces	tr.	extremely fine, clastic silt matrix; high abundances of mica/combustion flocs
3	2 m	20	70	10	silt	3	70	5	10	10	-	traces	traces	tr.	traces	traces	-	traces	tr.	fine silt matrix; rounded to well rounded quartz in coarse fraction
	11 m	10	80	10	silt	3	80	5	traces	10	traces	-	traces	tr.	traces	traces	-	traces	tr.	less rounded quartz particles
	18 m	40	50	10	silt	3	55	35	5	-	traces	-	traces	tr.	traces	traces	traces	traces	-	high abundances of rounded, coarse, clastics and angular silt-sized particles
4	1 m	40	50	10	sandy silt	4	55	35	5	tr.	traces	-	traces	tr.	traces	traces	-	traces	-	high abundance of rounded coarse clastics
	5 m	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	extremely little clastic components, only fluffs
	9 m	50	40	10	sandy silt	4	50	35	traces	10	traces	-	-	-	traces	traces	-	-	-	little clastic material; rounded clastics in coarse fraction
5	1 m	20	60	20	silt	5	75	15	traces	tr.	traces	-	5	-	traces	traces	-	-	-	little material; rounded particles in coarse fraction
	10 m	30	50	20	sandy silt	5	70	20	traces	5	traces	-	traces	-	traces	traces	-	-	-	little material; rounded particles in coarse fraction
	20 m	30	50	20	sandy silt	5	70	20	traces	5	traces	-	traces	-	traces	traces	-	-	-	little material; rounded particles in coarse fraction
6	1 m	35	50	15	sandy silt	6	75	10	traces	tr.	traces	-	traces	-	10	traces	-	-	tr.	abundance of angular, dark minerals in coarse fraction
	20 m	20	70	10	silt	6	80	traces	traces	tr.	traces	-	traces	-	15	traces	-	-	-	dark minerals of less diameter as in surface sample
	40 m	15	80	5	silt	6	85	5	traces	tr.	traces	-	traces	-	5	traces	traces	traces	-	coarse silt matrix; less sand-sized clastic particles as in surface sample
7	1 m	15	75	10	silt	7	80	10	traces	tr.	traces	-	traces	-	5	traces	-	-	tr.	-
	20 m	40	50	10	sandy silt	7	70	20	traces	tr.	traces	-	traces	-	5	traces	-	-	-	high abundance of (well)rounded clastic particles in coarse fraction (≈500µm) above the weak halocline
	37 m	20	70	10	silt	7	80	10	-	tr.	traces	-	traces	-	5	traces	-	-	-	coarse fraction ≈100µm; medium to coarse silt matrix
8	2 m	50*	40	10	silty sand	8	40	5	-	tr.	traces	-	traces	-	traces	traces	50*	traces	-	*high abundance of Copepods in coarse fraction; traces of spherical fly ashes
	7 m	50*	40	10	silty sand	8	45	5	-	5	traces	-	traces	-	traces	traces	40*	traces	-	*high abundance of Copepods in coarse fraction; medium to silt sized clastics
	12 m	40	50	10	sandy silt	8	70	5	traces	5	traces	-	traces	-	traces	traces	10	5	-	higher abundances of rounded, coarse quartz; abundances of spherical fly ashes

Table 6: Grain size distribution and sample composition of particulate matter in the snow cover.

Grain Size (in %)					Components (in %)														
Station #	Sand %	Silt %	Clay %	Sediment type	Station #	Quartz, Fsp. angular	Quartz, Fsp. (sub)angular	Fluffs	Rock fragments	Mica	Combustion products	Clay Min.*	Opaque minerals	Heavy min.	Diatoms, spores etc.	Plant debris	Fossil raisin	Remarks
1	10	80	10	silt	1	80	-	10	traces	tr.	traces	tr.	traces	tr.	-	5	-	fluffs, quartz and comb. products in coarse fraction
2	30	65	5	sandy silt	2	50	-	35	traces	tr.	5	tr.	traces	tr.	-	5	tr.	high abund. of fluffs in coarse fraction; less qu. a. comb. prod.
3	30	65	5	sandy silt	3	30	-	50	traces	tr.	5	tr.	5	tr.	-	5	tr.	fluffs, comb. prod. and quartz (subangular) in coarse fraction
4	30	50	20	sandy silt	4	55	15	20	traces	tr.	traces	tr.	traces	tr.	-	5	tr.	subangular to subrounded quartz in coarse fraction
6	40	50	10	sandy silt	6	60	-	35	traces	tr.	traces	tr.	traces	tr.	-	5	tr.	hi. abund. of fluffs in coarse fract.; less clast. particl.; much fine silt

Table 7: 137Cs activities in surface deposits and surface water samples of the SW Kara Sea.

Station #	Sediment (Bq/kg)	Water Bq(m^3)
1	0.33	4.9
2	2.60	-
3	1.70	-
4	0.33	5.1
5	1.00	-
6	13.0	5.3
7	14.2	-
8	20.2	-

Table 8: Areal lead extent, ice production rates and sediment entrainment in the SW Kara Sea.

Lead section (box)	Lead area (km^2)	Ice volume (km^3)	Sediment concentr. (mg/l)	Sediment entrained (t)	Sediment exported (t)
A	450*	7*	-	-	-
B	1200*	17*	-	-	-
C	1800*	11*	-	-	-
D	*450*	*7*	*11*	*77,000*	*0 - 7700*

*4-year mean from MARTIN and CAVALIERI (1989)

Table 9: Entrained and exported rates of 137Cs in Amderma/Vaygach lead-ice sediments based on minimum and maximum contamination levels in local surface deposits.

Lead	137Cs					
section (box)	Sediment minimum (Bq/kg)	Sediment maximum (Bq/kg)	Entrained minimum (GBq°)	Entrained maximum (GBq°)	Exported minimum (GBq°)	Exported maximum (GBq°)
D	0.33	20.2	0.25	15	0-0.025	0-1.5

°: GBq = 1x10exp9 Bq

Folgende Hefte der Reihe „Berichte zur Polarforschung" sind bisher erschienen:

* **Sonderheft Nr. 1/1981** – „Die Antarktis und ihr Lebensraum"
Eine Einführung für Besucher – Herausgegeben im Auftrag von SCAR

Heft Nr. 1/1982 – „Die Filchner-Schelfeis-Expedition 1980/81"
zusammengestellt von Heinz Kohnen

* **Heft-Nr. 2/1982** – „Deutsche Antarktis-Expedition1980/81 mit FS ‚Meteor'"
First International BIOMASS Experiment (FIBEX) – Liste der Zooplankton- und Mikronektonnetzfänge
zusammengestellt von Norbert Klages.

Heft Nr. 3/1982 – „Digitale und analoge Krill-Echolot-Rohdatenerfassung an Bord des Forschungsschiffes ‚Meteor'" (im Rahmen von FIBEX 1980/81, Fahrtabschnitt ANT III), von Bodo Morgenstern

Heft Nr. 4/1982 – „Filchner-Schelfeis-Expedition 1980/81"
Liste der Planktonfänge und Lichtstärkemessungen
zusammengestellt von Gerd Hubold und H. Eberhard Drescher

* **Heft Nr. 5/1982** – "Joint Biological Expedition on RRS 'John Biscoe', February 1982"
by G. Hempel and R. B. Heywood

* **Heft Nr. 6/1982** – „Antarktis-Expedition 1981/82 (Unternehmen ‚Eiswarte')"
zusammengestellt von Gode Gravenhorst

Heft Nr. 7/1982 – „Marin-Biologisches Begleitprogramm zur Standorterkundung 1979/80 mit MS ‚Polarsirkel' (Pre-Site Survey)" – Stationslisten der Mikronekton- und Zooplanktonfänge sowie der Bodenfischerei
zusammengestellt von R. Schneppenheim

Heft Nr. 8/1983 – "The Post-Fibex Data Interpretation Workshop"
by D. L. Cram and J.-C. Freytag with the collaboration of J. W. Schmidt, M. Mall, R. Kresse, T. Schwinghammer

* **Heft Nr. 9/1983** – "Distribution of some groups of zooplankton in the inner Weddell Sea in summer 1979/80"
by I. Hempel, G. Hubold, B. Kaczmaruk, R. Keller, R. Weigmann-Haass

Heft Nr. 10/1983 – „Fluor im antarktischen Ökosystem" – DFG-Symposium November 1982
zusammengestellt von Dieter Adelung

Heft Nr. 11/1983 – "Joint Biological Expedition on RRS 'John Biscoe', February 1982 (II)"
Data of micronecton and zooplankton hauls, by Uwe Piatkowski

Heft Nr. 12/1983 – „Das biologische Programm der ANTARKTIS-I-Expedition 1983 mit FS ‚Polarstern'"
Stationslisten der Plankton-, Benthos- und Grundschleppnetzfänge und Liste der Probennahme an Robben und Vögeln, von H. E. Drescher, G. Hubold, U. Piatkowski, J. Plötz und J. Voß

* **Heft Nr. 13/1983** – „Die Antarktis-Expedition von MS ‚Polarbjörn' 1982/83" (Sommerkampagne zur Atka-Bucht und zu den Kraul-Bergen), zusammengestellt von Heinz Kohnen

* **Sonderheft Nr. 2/1983** – „Die erste Antarktis-Expedition von FS ‚Polarstern' (Kapstadt, 20. Januar 1983 – Rio de Janeiro, 25. März 1983)", Bericht des Fahrtleiters Prof. Dr. Gotthilf Hempel

Sonderheft Nr. 3/1983 – „Sicherheit und Überleben bei Polarexpeditionen"
zusammengestellt von Heinz Kohnen

* **Heft Nr. 14/1983** – „Die erste Antarktis-Expedition (ANTARKTIS I) von FS ‚Polarstern' 1982/83"
herausgegeben von Gotthilf Hempel

Sonderheft Nr. 4/1983 – "On the Biology of Krill *Euphausia superba*" – Proceedings of the Seminar and Report of the Krill Ecology Group, Bremerhaven 12.–16. May 1983, edited by S. B. Schnack

Heft Nr. 15/1983 – "German Antarctic Expedition 1980/81 with FRV 'Walther Herwig' and RV 'Meteor'" – First International BIOMASS Experiment (FIBEX) – Data of micronekton and zooplankton hauls
by Uwe Piatkowski and Norbert Klages

Sonderheft Nr. 5/1984 – "The observatories of the Georg von Neumayer Station", by Ernst Augstein

Heft Nr. 16/1984 – "FIBEX cruise zooplankton data"
by U. Piatkowski, I. Hempel and S. Rakusa-Suszczewski

Heft Nr. 17/1984 – „Fahrtbericht (cruise report) der ‚Polarstern'-Reise ARKTIS I, 1983"
von E. Augstein, G. Hempel und J. Thiede

Heft Nr. 18/1984 – „Die Expedition ANTARKTIS II mit FS ‚Polarstern' 1983/84",
Bericht von den Fahrtabschnitten 1, 2 und 3, herausgegeben von D. Fütterer

Heft Nr. 19/1984 – „Die Expedition ANTARKTIS II mit FS ‚Polarstern' 1983/84",
Bericht vom Fahrtabschnitt 4, Punta Arenas–Kapstadt (Ant-II/4), herausgegeben von H. Kohnen

Heft Nr. 20/1984 – „Die Expedition ARKTIS II des FS ‚Polarstern' 1984, mit Beiträgen des FS ‚Valdivia' und des Forschungsflugzeuges ‚Falcon 20' zum Marginal Ice Zone Experiment 1984 (MIZEX)"
von E. Augstein, G. Hempel, J. Schwarz, J. Thiede und W. Weigel

Heft Nr. 21/1985 – "Euphausiid larvae in plankton samples from the vicinity of the Antarctic Peninsula, February 1982" by Sigrid Marschall and Elke Mizdalski
Heft Nr. 22/1985 – "Maps of the geographical distribution of macrozooplankton in the Atlantic sector of the Southern Ocean" by Uwe Piatkowski
Heft Nr. 23/1985 – „Untersuchungen zur Funktionsmorphologie und Nahrungsaufnahme der Larven des Antarktischen Krills *Euphausia superba* Dana" von Hans-Peter Marschall
Heft Nr. 24/1985 – „Untersuchungen zum Periglazial auf der König-Georg-Insel Südshetlandinseln/ Antarktika. Deutsche physiogeographische Forschungen in der Antarktis. – Bericht über die Kampagne 1983/84" von Dietrich Barsch, Wolf-Dieter Blümel, Wolfgang Flügel, Roland Mäusbacher, Gerhard Stablein, Wolfgang Zick
* **Heft-Nr. 25/1985** – „Die Expedition ANTARKTIS III mit FS ‚Polarstern' 1984/1985" herausgegeben von Gotthilf Hempel.
***Heft-Nr. 26/1985** – "The Southern Ocean"; A survey of oceanographic and marine meteorological research work by Hellmer et al.
Heft Nr. 27/1986 – „Spätpleistozäne Sedimentationsprozesse am antarktischen Kontinentalhang vor Kapp Norvegia, östliche Weddell-See" von Hannes Grobe
Heft Nr. 28/1986 – „Die Expedition ARKTIS III mit ‚Polarstern' 1985" mit Beiträgen der Fahrtteilnehmer, herausgegeben von Rainer Gersonde
* **Heft Nr. 29/1986** – „5 Jahre Schwerpunktprogramm ‚Antarktisforschung' der Deutschen Forschungsgemeinschaft." Rückblick und Ausblick. Zusammengestellt von Gotthilf Hempel, Sprecher des Schwerpunktprogramms
Heft Nr. 30/1986 – "The Meteorological Data of the Georg-von-Neumayer-Station for 1981 and 1982" by Marianne Gube and Friedrich Obleitner
Heft Nr. 31/1986 – „Zur Biologie der Jugendstadien der Notothenioidei (Pisces) an der Antarktischen Halbinsel" von A. Kellermann
Heft Nr. 32/1986 – „Die Expedition ANTARKTIS IV mit FS ‚Polarstern' 1985/86" mit Beiträgen der Fahrtteilnehmer, herausgegeben von Dieter Fütterer
Heft Nr. 33/1987 – „Die Expedition ANTARKTIS-IV mit FS ‚Polarstern' 1985/86 – Bericht zu den Fahrtabschnitten ANT-IV/3–4" von Dieter Karl Fütterer
Heft Nr. 34/1987 – „Zoogeographische Untersuchungen und Gemeinschaftsanalysen an antarktischem Makroplankton" von U. Piatkowski
Heft Nr. 35/1987 – „Zur Verbreitung des Meso- und Makrozooplanktons in Oberflächenwasser der Weddell See (Antarktis)" von E. Boysen-Ennen
Heft Nr. 36/1987 – „Zur Nahrungs- und Bewegungsphysiologie von *Salpa thompsoni* und *Salpa fusiformis*" von M. Reinke
Heft Nr. 37/1987 – "The Eastern Weddell Sea Drifting Buoy Data Set of the Winter Weddell Sea Project (WWSP)" 1986 by Heinrich Hoeber und Marianne Gube-Lehnhardt
Heft Nr. 38/1987 – "The Meteorological Data of the Georg von Neumayer Station for 1983 and 1984" by M. Gube-Lenhardt
Heft Nr. 39/1987 – „Die Winter-Expedition mit FS ‚Polarstern' in die Antarktis (ANT V/1–3)" herausgegeben von Sigrid Schnack-Schiel
Heft Nr. 40/1987 – "Weather and Synoptic Situation during Winter Weddell Sea Project 1986 (ANT V/2) July 16–September 10, 1986" by Werner Rabe
Heft Nr. 41/1988 – „Zur Verbreitung und Ökologie der Seegurken im Weddellmeer (Antarktis)" von Julian Gutt
Heft Nr. 42/1988 – "The zooplankton community in the deep bathyal and abyssal zones of the eastern North Atlantic" by Werner Beckmann
Heft Nr. 43/1988 – "Scientific cruise report of Arctic Expedition ARK IV/3" Wissenschaftlicher Fahrtbericht der Arktis-Expedition ARK IV/3, compiled by Jörn Thiede
Heft Nr. 44/1988 – "Data Report for FV 'Polarstern' Cruise ARK IV/1, 1987 to the Arctic and Polar Fronts" by Hans-Jürgen Hirche
Heft Nr. 45/1988 – „Zoogeographie und Gemeinschaftsanalyse des Makrozoobenthos des Weddellmeeres (Antarktis)" von Joachim Voß
Heft Nr. 46/1988 – "Meteorological and Oceanographic Data of the Winter-Weddell-Sea Project 1986 (ANT V/3)" by Eberhard Fahrbach
Heft Nr. 47/1988 – „Verteilung und Herkunft glazial-mariner Gerölle am Antarktischen Kontinentalrand des östlichen Weddellmeeres" von Wolfgang Oskierski
Heft Nr. 48/1988 – „Variationen des Erdmagnetfeldes an der GvN-Station" von Arnold Brodscholl
* **Heft Nr. 49/1988** – „Zur Bedeutung der Lipide im antarktischen Zooplankton" von Wilhelm Hagen
Heft Nr. 50/1988 – „Die gezeitenbedingte Dynamik des Ekström-Schelfeises, Antarktis" von Wolfgang Kobarg

Heft Nr. 51/1988 – „Ökomorphologie nototheniider Fische aus dem Weddellmeer, Antarktis" von Werner Ekau

Heft Nr. 52/1988 – „Zusammensetzung der Bodenfauna in der westlichen Fram-Straße" von Dieter Piepenburg

* **Heft Nr. 53/1988** – „Untersuchungen zur Ökologie des Phytoplanktons im südöstlichen Weddellmeer (Antarktis) im Jan./Febr. 1985" von Eva-Maria Nöthig

Heft Nr. 54/1988 – „Die Fischfauna des östlichen und südlichen Weddellmeeres: geographische Verbreitung, Nahrung und trophische Stellung der Fischarten" von Wiebke Schwarzbach

Heft Nr. 55/1988 – "Weight and length data of zooplankton in the Weddell Sea in austral spring 1986 (Ant V/3)" by Elke Mizdalski

Heft Nr. 56/1989 – "Scientific cruise report of Arctic expeditions ARK IV/1, 2 & 3" by G. Krause, J. Meincke und J. Thiede

Heft Nr. 57/1989 – „Die Expedition ANTARKTIS V mit FS ‚Polarstern' 1986/87" Bericht von den Fahrtabschnitten ANT V/4–5 von H. Miller und H. Oerter

* **Heft Nr. 58/1989** – „Die Expedition ANTARKTIS VI mit FS ‚Polarstern' 1987/88" von D. K. Fütterer

Heft Nr. 59/1989 – „Die Expedition ARKTIS V/1a, 1b und 2 mit FS ‚Polarstern' 1988" von M. Spindler

Heft Nr. 60/1989 – „Ein zweidimensionales Modell zur thermohalinen Zirkulation unter dem Schelfeis" von H. H. Hellmer

Heft Nr. 61/1989 – „Die Vulkanite im westlichen und mittleren Neuschwabenland, Vestfjella und Ahlmannryggen, Antarktika" von M. Peters

* **Heft-Nr. 62/1989** – "The Expedition ANTARKTIS VII/1 and 2 (EPOS I) of RV 'Polarstern' in 1988/89", by I. Hempel

Heft Nr. 63/1989 – „Die Eisalgenflora des Weddellmeeres (Antarktis): Artenzusammensetzung und Biomasse sowie Ökophysiologie ausgewählter Arten" von Annette Bartsch

Heft Nr. 64/1989 – "Meteorological Data of the G.-v.-Neumayer-Station (Antarctica)" by L. Helmes

Heft Nr. 65/1989 – „Expedition Antarktis VII/3 in 1988/89" by I. Hempel, P. H. Schalk, V. Smetacek

Heft Nr. 66/1989 – „Geomorphologisch-glaziologische Detailkartierung des arid-hochpolaren Borgmassivet, Neuschwabenland, Antarktika" von Karsten Brunk

Heft-Nr. 67/1990 – „Identification key and catalogue of larval Antarctic fishes", edited by Adolf Kellermann

Heft-Nr. 68/1990 – „The Expediton Antarktis VII/4 (Epos leg 3) and VII/5 of RV 'Polarstern' in 1989", edited by W. Arntz, W. Ernst, I. Hempel

Heft-Nr. 69/1990 – „Abhängigkeiten elastischer und rheologischer Eigenschaften des Meereises vom Eisgefüge", von Harald Hellmann

Heft-Nr. 70/1990 – „Die beschalten benthischen Mollusken (Gastropoda und Bivalvia) des Weddellmeeres, Antarktis", von Stefan Hain

Heft-Nr. 71/1990 – „Sedimentologie und Paläomagnetik an Sedimenten der Maudkuppe (Nordöstliches Weddellmeer)", von Dieter Cordes.

Heft-Nr. 72/1990 – „Distribution and abundance of planktonic copepods (Crustacea) in the Weddell Sea in summer 1980/81", by F. Kurbjeweit and S. Ali-Khan

Heft-Nr. 73/1990 – „Zur Frühdiagenese von organischem Kohlenstoff und Opal in Sedimenten des südlichen und östlichen Weddellmeeres", von M. Schlüter

Heft-Nr. 74/1990 – „Expeditionen ANTARKTIS-VIII/3 und VIII/4 mit FS ‚Polarstern' 1989" von Rainer Gersonde und Gotthilf Hempel

Heft-Nr. 75/1991 – „Quartäre Sedimentationsprozesse am Kontinentalhang des Süd-Orkey-Plateaus im nordwestlichen Weddellmeer (Antarktis)", von Sigrun Grünig

Heft-Nr. 76/1990 – „Ergebnisse der faunistischen Arbeiten im Benthal von King George Island (Südshetlandinseln, Antarktis)", von Martin Rauschert

Heft-Nr. 77/1990 – „Verteilung von Mikroplankton-Organismen nordwestlich der Antarktischen Halbinsel unter dem Einfluß sich ändernder Umweltbedingungen im Herbst", von Heinz Klöser

Heft-Nr. 78/1991 – „Hochauflösende Magnetostratigraphie spätquartärer Sedimente arktischer Meeresgebiete", von Norbert R. Nowaczyk

Heft-Nr. 79/1991 – „Ökophysiologische Untersuchungen zur Salinitäts- und Temperaturtoleranz antarktischer Grünalgen unter besonderer Berücksichtigung des ß-Dimethylsulfoniumpropionat (DMSP) - Stoffwechsels", von Ulf Karsten

Heft-Nr. 80/1991 – „Die Expedition ARKTIS VII/1 mit FS ‚Polarstern' 1990", herausgegeben von Jörn Thiede und Gotthilf Hempel

Heft-Nr. 81/1991 – „Paläoglaziologie und Paläozeanographie im Spätquartär am Kontinentalrand des südlichen Weddellmeeres, Antarktis", von Martin Melles

Heft-Nr. 82/1991 – „Quantifizierung von Meereseigenschaften: Automatische Bildanalyse von Dünnschnitten und Parametrisierung von Chlorophyll- und Salzgehaltsverteilungen", von Hajo Eicken

Heft-Nr. 83/1991 – „Das Fließen von Schelfeisen - numerische Simulationen mit der Methode der finiten Differenzen", von Jürgen Determann

Heft-Nr. 84/1991 – „Die Expedition ANTARKTIS-VIII/1-2, 1989 mit der Winter Weddell Gyre Study der Forschungsschiffe „Polarstern" und „Akademik Fedorov", von Ernst Augstein, Nikolai Bagriantsev und Hans Werner Schenke

Heft-Nr. 85/1991 – „Zur Entstehung von Unterwassereis und das Wachstum und die Energiebilanz des Meereises in der Atka Bucht, Antarktis", von Josef Kipfstuhl

Heft-Nr. 86/1991 – „Die Expedition ANTARKTIS-VIII mit „FS Polarstern" 1989/90. Bericht vom Fahrtabschnitt ANT-VIII / 5", von Heinz Miller und Hans Oerter

Heft-Nr. 87/1991 –"Scientific cruise reports of Arctic expeditions ARK VI / 1-4 of RV "Polarstern" in 1989", edited by G. Krause, J. Meincke & H. J. Schwarz

Heft-Nr. 88/1991 – „Zur Lebensgeschichte dominanter Copepodenarten (*Calanus finmarchicus, C. glacialis, C. hyperboreus, Metridia longa)* in der Framstraße", von Sabine Diel

Heft-Nr. 89/1991 – „Detaillierte seismische Untersuchungen am östlichen Kontinentalrand des Weddell-Meeres vor Kapp Norvegia, Antarktis", von Norbert E. Kaul

Heft-Nr. 90/1991 – „Die Expedition ANTARKTIS-VIII mit FS „Polarstern" 1989/90. Bericht von den Fahrtabschnitten ANT-VIII/6-7", herausgegeben von Dieter Karl Fütterer und Otto Schrems

Heft-Nr. 91/1991 – "Blood physiology and ecological consequences in Weddell Sea fishes (Antarctica)", by Andreas Kunzmann

Heft-Nr. 92/1991 – „Zur sommerlichen Verteilung des Mesozooplanktons im Nansen-Becken, Nordpolarmeer", von Nicolai Mumm

Heft-Nr. 93/1991 – „Die Expedition ARKTIS VII mit FS „Polarstern", 1990. Bericht vom Fahrtabschnitt ARK VII/2", herausgegeben von Gunther Krause

Heft-Nr. 94/1991 – „Die Entwicklung des Phytoplanktons im östlichen Weddellmeer (Antarktis) beim Übergang vom Spätwinter zum Frühjahr", von Renate Scharek

Heft-Nr. 95/1991 – „Radioisotopenstratigraphie, Sedimentologie und Geochemie jungquartärer Sedimente des östlichen Arktischen Ozeans", von Horst Bohrmann

Heft-Nr. 96/1991 – „Holozäne Sedimentationsentwicklung im Scoresby Sund, Ost-Grönland", von Peter Marienfeld

Heft-Nr. 97/1991 – „Strukturelle Entwicklung und Abkühlungsgeschichte der Heimefrontfjella (Westliches Dronning Maud Land/Antarktika)", von Joachim Jacobs

Heft-Nr. 98/1991 – „Zur Besiedlungsgeschichte des antarktischen Schelfes am Beispiel der Isopoda (Crustacea, Malacostraca)", von Angelika Brandt

Heft-Nr. 99/1992 – "The Antarctic ice sheet and environmental change: a three-dimensional modelling study", by Philippe Huybrechts

* **Heft-Nr. 100/1992** – „Die Expeditionen ANTARKTIS IX/1-4 des Forschungsschiffes „Polarstern" 1990/91", herausgegeben von Ulrich Bathmann, Meinhard Schulz-Baldes, Eberhard Fahrbach, Victor Smetacek und Hans-Wolfgang Hubberten

Heft-Nr. 101/1992 – „Wechselbeziehungen zwischen Schwermetallkonzentrationen (Cd, Cu, Pb, Zn) im Meewasser und in Zooplanktonorganismen (Copepoda) der Arktis und des Atlantiks", von Christa Pohl

Heft-Nr. 102/1992 – „Physiologie und Ultrastruktur der antarktischen Grünalge *Prasiola crispa* ssp. *antarctica* unter osmotischem Streß und Austrocknung", von Andreas Jacob

Heft-Nr. 103/1992 – „Zur Ökologie der Fische im Weddelmeer", von Gerd Hubold

Heft-Nr. 104/1992 – „Mehrkanalige adaptive Filter für die Unterdrückung von multiplen Reflexionen in Verbindung mit der freien Oberfläche in marinen Seismogrammen", von Andreas Rosenberger

Heft-Nr. 105/1992 – „Radiation and Eddy Flux Experiment 1991 *(REFLEX I)*", von Jörg Hartmann, Christoph Kottmeier und Christian Wamser

Heft-Nr. 106/1992 – „Ostracoden im Epipelagial vor der Antarktischen Halbinsel - ein Beitrag zur Systematik sowie zur Verbreitung und Populationsstruktur unter Berücksichtigung der Saisonalität", von Rüdiger Kock

Heft-Nr. 107/1992 – „ARCTIC '91: Die Expedition ARK-VIII/3 mit FS „Polarstern" 1991", von Dieter K. Fütterer

Heft-Nr. 108/1992 – „Dehnungsbeben an einer Störungszone im Ekström-Schelfeis nördlich der Georg-von-Neumayer Station, Antarktis. – Eine Untersuchung mit seismologischen und geodätischen Methoden", von Uwe Nixdorf.

Heft-Nr. 109/1992 – „Spätquartäre Sedimentation am Kontinentalrand des südöstlichen Weddellmeeres, Antarktis", von Michael Weber.

Heft-Nr. 110/1992 – „Sedimentfazies und Bodenwasserstrom am Kontinentalhang des nordwestlichen Weddellmeeres", von Isa Brehme.

Heft-Nr. 111/1992 – „Die Lebensbedingungen in den Solekanälchen des antarktischen Meereises", von Jürgen Weissenberger.

Heft-Nr. 112/1992 – „Zur Taxonomie von rezenten benthischen Foraminiferen aus dem Nansen Becken, Arktischer Ozean", von Jutta Wollenburg.

Heft-Nr. 113/1992 – „Die Expedition ARKTIS VIII/1 mit FS "Polarstern" 1991", herausgegeben von Gerhard Kattner.

* **Heft-Nr. 114/1992** – „Die Gründungsphase deutscher Polarforschung, 1865-1875", von Reinhard A. Krause.

Heft-Nr. 115/1992 – „Scientific Cruise Report of the 1991 Arctic Expedition ARK VIII/2 of RV "Polarstern" (EPOS II)", by Eike Rachor.

Heft-Nr. 116/1992 – „The Meteorological Data of the Georg-von-Neumayer-Station (Antarctica) for 1988, 1989, 1990 and 1991", by Gert König-Langlo.

Heft-Nr. 117/1992 – „Petrogenese des metamorphen Grundgebirges der zentralen Heimefrontfjella (westliches Dronning Maud Land / Antarktis)", von Peter Schulze.

Heft-Nr. 118/1993 – „Die mafischen Gänge der Shackleton Range / Antarktika: Petrographie, Geochemie, Isotopengeochemie und Paläomagnetik", von Rüdiger Hotten.

* **Heft-Nr. 119/1993** – „Gefrierschutz bei Fischen der Polarmeere", von Andreas P.A. Wöhrmann.

* **Heft-Nr. 120/1993** – „East Siberian Arctic Region Expedition '92: The Laptev Sea - its Significance for Arctic Sea-Ice Formation and Transpolar Sediment Flux", by D. Dethleff, D. Nürnberg, E. Reimnitz, M. Saarso and Y. P. Sacchenko. – „Expedition to Novaja Zemlja and Franz Josef Land with RV.'Dalnie Zelentsy'", by D. Nürnberg and E. Groth.

* **Heft-Nr. 121/1993** – „Die Expedition ANTARKTIS X/3 mit FS 'Polarstern' 1992", herausgegeben von Michael Spindler, Gerhard Dieckmann und David Thomas.

Heft-Nr. 122/1993 – „Die Beschreibung der Korngestalt mit Hilfe der Fourier-Analyse: Parametrisierung der morphologischen Eigenschaften von Sedimentpartikeln", von Michael Diepenbroek.

* **Heft-Nr. 123/1993** – „Zerstörungsfreie hochauflösende Dichteuntersuchungen mariner Sedimente", von Sebastian Gerland.

Heft-Nr. 124/1993 – „Umsatz und Verteilung von Lipiden in arktischen marinen Organismen unter besonderer Berücksichtigung unterer trophischer Stufen", von Martin Graeve.

Heft-Nr. 125/1993 – „Ökologie und Respiration ausgewählter arktischer Bodenfischarten", von Christian F. von Dorrien.

Heft-Nr. 126/1993 – „Quantitative Bestimmung von Paläoumweltparametern des Antarktischen Oberflächenwassers im Spätquartär anhand von Transferfunktionen mit Diatomeen", von Ulrich Zielinski

Heft-Nr. 127/1993 – „Sedimenttransport durch das arktische Meereis: Die rezente lithogene und biogene Materialfracht", von Ingo Wollenburg.

Heft-Nr. 128/1993 – „Cruise ANTARKTIS X/3 of RV 'Polarstern': CTD-Report", von Marek Zwierz.

Heft-Nr. 129/1993 – „Reproduktion und Lebenszyklen dominanter Copepodenarten aus dem Weddellmeer, Antarktis", von Frank Kurbjeweit

Heft-Nr. 130/1993 – „Untersuchungen zu Temperaturregime und Massenhaushalt des Filchner-Ronne-Schelfeises, Antarktis, unter besonderer Berücksichtigung von Anfrier- und Abschmelzprozessen", von Klaus Grosfeld

Heft-Nr. 131/1993 – „Die Expedition ANTARKTIS X/5 mit FS 'Polarstern' 1992", herausgegeben von Rainer Gersonde

Heft-Nr. 132/1993 – „Bildung und Abgabe kurzkettiger halogenierter Kohlenwasserstoffe durch Makroalgen der Polarregionen", von Frank Laturnus

Heft-Nr. 133/1994 – "Radiation and Eddy Flux Experiment 1993 *(REFLEX II)*", by Christoph Kottmeier, Jörg Hartmann, Christian Wamser, Axel Bochert, Christof Lüpkes, Dietmar Freese and Wolfgang Cohrs

* **Heft-Nr. 134/1994** – "The Expedition ARKTIS-IX/1", edited by Hajo Eicken and Jens Meincke

Heft-Nr. 135/1994 – „Die Expeditionen ANTARKTIS X/6-8", herausgegeben von Ulrich Bathmann, Victor Smetacek, Hein de Baar, Eberhard Fahrbach und Gunter Krause

Heft-Nr. 136/1994 – „Untersuchungen zur Ernährungsökologie von Kaiserpinguinen *(Aptenodytes forsteri)* und Königspinguinen *(Aptenodytes patagonicus)*", von Klemens Pütz

* **Heft-Nr. 137/1994** – „Die känozoische Vereisungsgeschichte der Antarktis", von Werner U. Ehrmann

Heft-Nr. 138/1994 – „Untersuchungen stratosphärischer Aerosole vulkanischen Ursprungs und polarer stratosphärischer Wolken mit einem Mehrwellenlängen-Lidar auf Spitzbergen *(79° N, 12° E)*", von Georg Beyerle

Heft-Nr. 139/1994 – „Charakterisierung der Isopodenfauna (Crustacea, Malacostraca) des Scotia-Bogens aus biogeographischer Sicht: Ein multivariater Ansatz", von Holger Winkler.

Heft-Nr. 140/1994 – „Die Expedition ANTARKTIS X/4 mit FS 'Polarstern' 1992", herausgegeben von Peter Lemke

Heft-Nr. 141/1994 – „Satellitenaltimetrie über Eis – Anwendung des GEOSAT-Altimeters über dem Ekströmisen, Antarktis", von Clemens Heidland

Heft-Nr. 142/1994 – "The 1993 Northeast Water Expedition. Scientific cruise report of RV'Polarstern' Arctic cruises ARK IX/2 and 3, USCG 'Polar Bear' cruise NEWP and the NEWLand expedition", edited by Hans-Jürgen Hirche and Gerhard Kattner

Heft-Nr. 143/1994 – „Detaillierte refraktionsseismische Untersuchungen im inneren Scoresby Sund Ost-Grönland", von Notker Fechner

Heft-Nr. 144/1994 – „Russian-German Cooperation in the Siberian Shelf Seas: Geo-System Laptev Sea", edited by Heidemarie Kassens, Hans-Wolfgang Hubberten, Sergey M. Pryamikov und Rüdiger Stein

* **Heft-Nr. 145/1994** – „The 1993 Northeast Water Expedition. Data Report of RV 'Polarstern' Arctic Cruises IX/2 and 3", edited by Gerhard Kattner and Hans-Jürgen Hirche.

Heft-Nr. 146/1994 – "Radiation Measurements at the German Antarctic Station Neumayer 1982-1992", by Torsten Schmidt and Gert König-Langlo.

Heft-Nr. 147/1994 – „Krustenstrukturen und Verlauf des Kontinentalrandes im Weddell Meer / Antarktis", von Christian Hübscher.

Heft-Nr. 148/1994 – "The expeditions NORILSK/TAYMYR 1993 and BUNGER OASIS 1993/94 of the AWI Research Unit Potsdam", edited by Martin Melles.

** **Heft-Nr. 149/1994** – "Die Expedition ARCTIC' 93. Der Fahrtabschnitt ARK-IX/4 mit FS 'Polarstern' 1993", herausgegeben von Dieter K. Fütterer.

Heft-Nr. 150/1994 – "Der Energiebedarf der Pygoscelis-Pinguine: eine Synopse", von Boris M. Culik.

Heft-Nr. 151/1994 – „Russian-German Cooperation: The Transdrift I Expedition to the Laptev Sea", edited by Heidemarie Kassens and Valeriy Y. Karpiy.

Heft-Nr. 152/1994 – „Die Expedition ANTARKTIS-X mit FS 'Polarstern' 1992. Bericht von den Fahrtabschnitten / ANT-X / 1a und 2", herausgegeben von Heinz Miller.

Heft-Nr. 153/1994 – "Aminosäuren und Huminstoffe im Stickstoffkreislauf polarer Meere", von Ulrike Hubberten.

Heft-Nr. 154/1994 – "Regional und seasonal variability in the vertical distribution of mesozooplankton in the Greenland Sea", by Claudio Richter.

Heft-Nr. 155/1995 – "Benthos in polaren Gewässern", herausgegeben von Christian Wiencke und Wolf Arntz.

Heft-Nr. 156/1995 – "An adjoint model for the determination of the mean oceanic circulation, air-sea fluxes und mixing coefficients", by Reiner Schlitzer.

Heft-Nr. 157/1995 – "Biochemische Untersuchungen zum Lipidstoffwechsel antarktischer Copepoden", von Kirsten Fahl.

** **Heft-Nr. 158/1995** – "Die Deutsche Polarforschung seit der Jahrhundertwende und der Einfluß Erich von Drygalskis", von Cornelia Lüdecke.

Heft-Nr. 159/1995 – The distribution of $\partial^{18}O$ in the Arctic Ocean: Implications for the freshwater balance of the haloclin and the sources of deep and bottom waters", by Dorothea Bauch.

* **Heft-Nr. 160/1995** – "Rekonstruktion der spätquartären Tiefenwasserzirkulation und Produktivität im östlichen Südatlantik anhand von benthischen Foraminiferenvergesellschaftungen", von Gerhard Schmiedl.

Heft-Nr. 161/1995 – "Der Einfluß von Salinität und Lichtintensität auf die Osmolytkonzentrationen, die Zellvolumina und die Wachstumsraten der antarktischen Eisdiatomeen *Chaetoceros* sp. und *Navicula* sp. unter besonderer Berücksichtigung der Aminosäure Prolin", von Jürgen Nothnagel.

Heft-Nr. 162/1995 – "Meereistransportiertes lithogenes Feinmaterial in spätquartären Tiefseesedimenten des zentraler östlichen Arktischen Ozeans und der Framstraße", von Thomas Letzig.

Heft-Nr. 163/1995 – "Die Expedition ANTARKTIS-XI/2 mit FS "Polarstern" 1993/94", herausgegeben von Rainer Gersonde.

Heft-Nr. 164/1995 – "Regionale und altersabhängige Variation gesteinsmagnetischer Parameter in marinen Sedimenten der Arktis", von Thomas Frederichs.

Heft-Nr. 165/1995 – "Vorkommen, Verteilung und Umsatz biogener organischer Spurenstoffe: Sterole in antarktischen Gewässern", von Georg Hanke.

Heft-Nr. 166/1995 – "Vergleichende Untersuchungen eines optimierten dynamisch-thermodynamischen Meereismode mit Beobachtungen im Weddellmeer", von Holger Fischer.

Heft-Nr. 167/1995 – "Rekonstruktionen von Paläo-Umweltparametern anhand von stabilen Isotopen und Faunen-Vergesellschaftungen planktischer Foraminiferen im Südatlantik", von Hans-Stefan Niebler

Heft-Nr. 168/1995 – "Die Expedition ANTARKTIS XII mit FS 'Polarstern' 1993/94. Bericht von den Fahrtabschnitten ANT XII/1 und 2", herausgegeben von Gerhard Kattner und Dieter Karl Fütterer.

Heft-Nr. 169/1995 – "Medizinische Untersuchung zur Circadianrhythmik und zum Verhalten bei Überwinterern auf ein antarktischen Forschungsstation", von Hans Wortmann.

Heft-Nr. 170/1995 – DFG-Kolloquium: Terrestrische Geowissenschaften - Geologie und Geophysik der Antarktis.

Heft-Nr. 171/1995 – "Strukturentwicklung und Petrogenese des metamorphen Grundgebirges der nördlichen Heimefrontfjella (westliches Dronning Maud Land/Antarktika)", von Wilfried Bauer.

Heft-Nr. 172/1995 – "Die Struktur der Erdkruste im Bereich des Scoresby Sund, Ostgrönland: Ergebnisse refraktionsseismischer und gravimetrischer Untersuchungen", von Holger Mandler.

Heft-Nr. 173/1995 – "Paläozoische Akkretion am paläopazifischen Kontinentalrand der Antarktis in Nordvictorialand – P-T-D-Geschichte und Deformationsmechanismen im Bowers Terrane", von Stefan Matzer.

Heft-Nr. 174/1995 – "The Expedition ARKTIS-X/2 of RV 'Polarstern' in 1994", edited by Hans-W. Hubberten.

Heft-Nr. 175/1995 – "Russian-German Cooperation: The Expedition TAYMYR 1994", edited by Christine Siegert and Dmitry Bolshiyanov.

Heft-Nr. 176/1995 – "Russian-German Cooperation: Laptev Sea System", edited by Heidemarie Kassens, Dieter Piepenburg, Jörn Thiede, Leonid Timokhov, Hans-Wolfgang Hubberten and Sergey M. Priamikov.

Heft-Nr. 177/1995 – "Organischer Kohlenstoff in spätquartären Sedimenten des Arktischen Ozeans: Terrigener Eintra und marine Produktivität", von Carsten J. Schubert.

Heft-Nr. 178/1995 – "Cruise ANTARKTIS XII/4 of RV 'Polarstern' in 1995: CTD-Report", by Jüri Sildam.

Heft-Nr. 179/1995 – "Benthische Foraminiferenfaunen als Wassermassen-, Produktions- und Eisdriftanzeiger im Arkt schen Ozean", von Jutta Wollenburg.

Heft-Nr. 180/1995 – "Biogenopal und biogenes Barium als Indikatoren für spätquartäre Produktivitätsänderungen am antarktischen Kontinentalhang, atlantischer Sektor", von Wolfgang J. Bonn.

Heft-Nr. 181/1995 – "Die Expedition ARKTIS X/1 des Forschungsschiffes ‚Polarstern' 1994", herausgegeben von Eberhard Fahrbach.

Heft-Nr. 182/1995 – "Laptev Sea System: Expeditions in 1994", edited by Heidemarie Kassens.

Heft-Nr. 183/1996 – "Interpretation digitaler Parasound Echolotaufzeichnungen im östlichen Arktischen Ozean auf dei Grundlage physikalischer Sedimenteigenschaften", von Uwe Bergmann.

Heft-Nr. 184/1996 – "Distribution and dynamics of inorganic nitrogen compounds in the troposphere of continental, coastal, marine and Arctic areas", by María Dolores Andrés Hernández.

Heft-Nr. 185/1996 – "Verbreitung und Lebensweise der Aphroditiden und Polynoiden (Polychaeta) im östlichen Wedd meer und im Lazarevmeer (Antarktis)", von Michael Stiller.

Heft-Nr. 186/1996 – "Reconstruction of Late Quaternary environmental conditions applying the natural radionuclides ^{230}Th, ^{10}Be, ^{231}Pa and ^{238}U: A study of deep-sea sediments from the eastern sector of the Antrctic Circumpolar Current System", by Martin Frank.

Heft-Nr. 187/1996 – "The Meteorological Data of the Neumayer Station (Antarctica) for 1992, 1993 and 1994", by Gert König-Langlo and Andreas Herber.

Heft-Nr. 188/1996 – "Die Expedition ANTARKTIS-XI/3 mit FS 'Polarstern' 1994", herausgegeben von Heinz Miller und Hannes Grobe.

Heft-Nr. 189/1996 – "Die Expedition ARKTIS-VII/3 mit FS 'Polarstern' 1990", herausgegeben von Heinz Miller und Hannes Grobe.

Heft-Nr. 190/1996 – "Cruise report of the Joint Chilean-German-Italian Magellan 'Victor Hensen' Campaign in 1994", edited by Wolf Arntz and Matthias Gorny.

Heft-Nr. 191/1996 – "Leitfähigkeits- und Dichtemessung an Eisbohrkernen", von Frank Wilhelms.

Heft-Nr. 192/1996 – "Photosynthese-Charakteristika und Lebensstrategie antarktischer Makroalgen", von Gabriele Weykam.

Heft-Nr. 193/1996 – "Heterogene Raktionen von N_2O_5 und HBr und ihr Einfluß auf den Ozonabbau in der polaren Stratosphäre", von Sabine Seisel.

Heft-Nr. 194/1996 – "Ökologie und Populationsdynamik antarktischer Ophiuroiden (Echinodermata)", von Corinna Dahm.

Heft-Nr. 195/1996 – "Die planktische Foraminifere *Neogloboquadrina pachyderma* (Ehrenberg) im Weddellmeer, Antarktis", von Doris Berberich.

Heft-Nr. 196/1996 – "Untersuchungen zum Beitrag chemischer und dynamischer Prozesse zur Variabilität des stratosphärischen Ozons über der Arktis", von Birgit Heese.

Heft-Nr. 197/1996 – "The Expedition ARKTIS-XI/2 of 'Polarstern' in 1995", edited by Gunther Krause.

Heft-Nr. 198/1996 – "Geodynamik des Westantarktischen Riftsystems basierend auf Apatit-Spaltspuranalysen", von Frank Lisker.

Heft-Nr. 199/1996 – "The 1993 Northeast Water Expedition. Data Report on CTD Measurements of RV 'Polarstern' Cruises ARKTIS IX/2 and 3", by Gereon Budéus and Wolfgang Schneider.

Heft-Nr. 200/1996 – "Stability of the Thermohaline Circulation in analytical and numerical models", by Gerrit Lohmann

Heft-Nr. 201/1996 – "Trophische Beziehungen zwischen Makroalgen und Herbivoren in der Potter Cove (King George-Insel, Antarktis)", von Katrin Iken.

Heft-Nr. 202/1996 – "Zur Verbreitung und Respiration ökologisch wichtiger Bodentiere in den Gewässern um Svalbard (Arktis)", von Michael K. Schmid.

Heft-Nr. 203/1996 – "Dynamik, Rauhigkeit und Alter des Meereises in der Arktis - Numerische Untersuchungen mit einem großskaligen Modell", von Markus Harder.

Heft-Nr. 204/1996 – "Zur Parametrisierung der stabilen atmosphärischen Grenzschicht über einem antarktischen Schelfeis", von Dörthe Handorf.

Heft-Nr. 205/1996 – "Textures and fabrics in the GRIP ice core, in relation to climate history and ice deformation", by Thorsteinn Thorsteinsson.

Heft-Nr. 206/1996 – "Der Ozean als Teil des gekoppelten Klimasystems: Versuch der Rekonstruktion der glazialen Zirkulation mit verschieden komplexen Atmosphärenkomponenten", von Kerstin Fieg.

Heft-Nr. 207/1996 – "Lebensstrategien dominanter antarktischer Oithonidae (Cyclopoida, Copepoda) und Oncaeidae (Poecilostomatoida, Copepoda) im Bellingshausenmeer", von Cornelia Metz.

Heft-Nr. 208/1996 – "Atmosphäreneinfluß bei der Fernerkundung von Meereis mit passiven Mikrowellenradiometern", von Christoph Oelke.

Heft-Nr. 209/1996 – "Klassifikation von Radarsatellitendaten zur Meereiserkennung mit Hilfe von Line-Scanner-Messu gen", von Axel Bochert.

Heft-Nr. 210/1996 – "Die mit ausgewählten Schwämmen (Hexactinellida und Demospongiae) aus dem Weddellmeer, Antarktis, vergesellschaftete Fauna", von Kathrin Kunzmann.

Heft-Nr. 211/1996 – "Russian-German Cooperation: The Expediton TAYMYR 1995 and the Expedition KOLYMA 19 by Dima Yu. Bolshiyanov and Hans-W. Hubberten.

Heft-Nr. 212/1996 – "Surface-sediment composition and sedimentary processes in the central Arctic Ocean and al the Eurasian Continental Margin", by Ruediger Stein, Gennadij I. Ivanov, Michael A. Levitan, and Kirsten Fahl.

Heft-Nr. 213/1996 – "Gonadenentwicklung und Eiproduktion dreier *Calanus*-Arten (Copepoda): Freilandbeobachtur Histologie und Experimente", von Barbara Niehoff.

Heft-Nr. 214/1996 – "Numerische Modellierung der Übergangszone zwischen Eisschild und Eisschelf", von Christo Mayer.

Heft-Nr. 215/1996 – "Arbeiten der AWI-Forschungsstelle Potsdam in Antarktika, 1994/95", herausgegeben von Ulri Wand.

Heft-Nr. 216/1996 – "Rekonstruktion quartärer Klimaänderungen im atlantischen Sektor des Südpolarmeeres anhar von Radiolarien", von Uta Brathauer.

Heft-Nr. 217/1996 – "Adaptive Semi-Lagrange-Finite-Elemente-Methode zur Lösung der Flachwassergleichungen: Implementierung und Parallelisierung", von Jörn Behrens.

Heft-Nr. 218/1997 – "Radiation and Eddy Flux Experiment 1995 (REFLEX III)", by Jörg Hartmann, Axel Bochert, Dietmar Freese, Christoph Kottmeier, Dagmar Nagel and Andreas Reuter.

Heft-Nr. 219/1997 – "Die Expedition ANTARKTIS-XII mit FS 'Polarstern' 1995. Bericht vom Fahrtabschnitt ANT-XII/: herausgegeben von Wilfried Jokat und Hans Oerter.

Heft-Nr. 220/1997 – "Ein Beitrag zum Schwerefeld im Bereich des Weddellmeeres, Antarktis. Nutzung von Altimetermessungen des GEOSAT und ERS-1", von Tilo Schöne.

Heft-Nr. 221/1997 – "Die Expeditionen ANTARKTIS-XIII/1-2 des Forschungsschiffes 'Polarstern' 1995/96", herausgegeben von Ulrich Bathmann, Mike Lucas und Victor Smetacek.

Heft-Nr. 222/1997 – "Tectonic Structures and Glaciomarine Sedimentation in the South-Eastern Weddell Sea from Seismic Reflection Data", by László Oszkó.

Heft-Nr. 223/1997 – "Bestimmung der Meereisdicke mit seismischen und elektromagnetisch-induktiven Verfahren", von Christian Haas.

Heft-Nr. 224/1997 – "Troposphärische Ozonvariationen in Polarregionen", von Silke Wessel.

Heft-Nr. 225/1997 – "Biologische und ökologische Untersuchungen zur kryopelagischen Amphipodenfauna des arktischen Meereises", von Michael Poltermann.

Heft-Nr. 226/1997 – "Scientific Cruise Report of the Arctic Expedition ARK-XI/1 of RV 'Polarstern' in 1995", edited by Eike Rachor.

Heft-Nr. 227/1997 – "Der Einfluß kompatibler Substanzen und Kryoprotektoren auf die Enzyme Malatdehydrogenas (MDH) und Glucose-6-phosphat-Dehydrogenase (G6P-DH) aus *Acrosiphonia arcta* (Chlorophyta der Arktis", von Katharina Kück.

Heft-Nr. 228/1997 – "Die Verbreitung epibenthischer Mollusken im chilenischen Beagle-Kanal", von Katrin Linse.

Heft-Nr. 229/1997 – "Das Mesozooplankton im Laptevmeer und östlichen Nansen-Becken - Verteilung und Gemeinschaftsstrukturen im Spätsommer", von Hinrich Hanssen.

Heft-Nr. 230/1997 – "Modell eines adaptierbaren, rechnergestützten, wissenschaftlichen Arbeitsplatzes am Alfred-Wegener-Institut für Polar- und Meeresforschung", von Lutz-Peter Kurdelski.

Heft-Nr. 231/1997 – "Zur Ökologie arktischer und antarktischer Fische: Aktivität, Sinnesleistungen und Verhalten", von Christopher Zimmermann.

Heft-Nr. 232/1997 – "Persistente clororganische Verbindungen in hochantarktischen Fischen", von Stephan Zimmermann.

Heft-Nr. 233/1997 – "Zur Ökologie des Dimethylsulfoniumpropionat (DMSP)-Gehaltes temperierter und polarer Phytoplanktongemeinschaften im Vergleich mit laborkulturen der Coccolithophoride *Emiliania huxleyi* und der antarktischen Diatomee *Nitzschia lecointei*", von Doris Meyerdierks.

Heft-Nr. 234/1997 – "Die Expedition ARCTIC '96 des FS 'Polarstern' (ARK XII) mit der Arctic Climate System Study (ACSYS)", von Ernst Augstein und den Fahrtteilnehmern.

Heft-Nr. 235/1997 – "Polonium-210 und Blei-219 im Südpolarmeer: Natürliche Tracer für biologische und hydrographische Prozesse im Oberflächenwasser des Antarktischen Zirkumpolarstroms und des Weddellmeeres", von Jana Friedrich.

Heft-Nr. 236/1997 – "Determination of atmospheric trace gas amounts and corresponding natural isotopic rations b means of ground-based FTIR spectroscopy in the high Arctic", by Arndt Meier.

Heft-Nr. 237/1997 – "Russian-German Cooperation: The Expedition TAYMYR / SEVERNAYA ZEMLYA 1996", edited by Martin Melles, Birgit Hagedorn and Dmitri Yu. Bolshiyanow.

Heft-Nr. 238/1997 – "Life strategy and ecophysiology of Antarctic macroalgae", by Iván M. Gómez.

Heft-Nr. 239/1997 – "Die Expedition ANTARKTIS XIII/4-5 des Forschungsschiffes 'Polarstern' 1996", herausgegeben von Eberhard Fahrbach und Dieter Gerdes.

Heft-Nr. 240/1997 – "Untersuchungen zur Chrom-Speziation im Meerwasser, Meereis und Schnee aus ausgewählte Gebieten der Arktis", von Heide Giese.

Heft-Nr. 241/1997 – "Late Quaternary glacial history and paleoceanographic reconstructions along the East Greenland continental margin: Evidence from high-resolution records of stable isotopes and ice-rafted debris", by Seung-Il Nam.

Heft-Nr. 242/1997 – "Thermal, hydrological and geochemical dynamics of the active layer at a continuous site, Taymyr Peninsula, Siberia", by Julia Boike.

Heft-Nr. 243/1997 – "Zur Paläoozeanographie hoher Breiten: Stellvertreterdaten aus Foraminiferen", von Andreas Mackensen.

Heft-Nr. 244/1997 – "The Geophysical Observatory at Neumayer Station, Antarctica. Geomagnetic and seismological observations in 1995 and 1996", by Alfons Eckstaller, Thomas Schmidt, Viola Gaw, Christian Müller and Johannes Rogenhagen.

Heft-Nr. 245/1997 – "Temperaturbedarf und Biogeographie mariner Makroalgen - Anpassung mariner Makroalgen an tiefe Temperaturen", von Bettina Bischoff-Bäsmann.

Heft-Nr. 246/1997 – "Ökologische Untersuchungen zur Fauna des arktischen Meereises", von Christine Friedrich.

Heft-Nr. 247/1997 – "Entstehung und Modifizierung von marinen gelösten organischen Substanzen", von Berit Kirchhoff.

Heft-Nr. 248/1997 – "Laptev Sea System: Expeditions in 1995", edited by Heidemarie Kassens.

Heft-Nr. 249/1997 – "The Expedition ANTARKTIS XIII/3 (EASIZ I) of RV 'Polarstern' to the eastern Weddell Sea in 1996", edited by Wolf Arntz and Julian Gutt.

Heft-Nr. 250/1997 – "Vergleichende Untersuchungen zur Ökologie und Biodiversität des Mega-Epibenthos der Arktis und Antarktis", von Andreas Starmans.

Heft-Nr. 251/1997 – "Zeitliche und räumliche Verteilung von Mineralvergesellschaftungen in spätquartären Sedimenten des Arktischen Ozeans und ihre Nützlichkeit als Klimaindikatoren während der Glazial/Interglazial-Wechsel", von Christoph Vogt.

Heft-Nr. 252/1997 – "Solitäre Ascidien in der Potter Cove (King George Island, Antarktis). Ihre ökologische Bedeutung und Populationsdynamik", von Stephan Kühne.

Heft-Nr. 253/1997 – "Distribution and role of microprotozoa in the Southern Ocean", by Christine Klaas.

Heft-Nr. 254/1997 – "Die spätquartäre Klima- und Umweltgeschichte der Bunger-Oase, Ostantarktis", von Thomas Kulbe.

Heft-Nr. 255/1997 – "Scientific Cruise Report of the Arctic Expedition ARK-XIII/2 of RV 'Polarstern' in 1997", edited by Ruediger Stein and Kirsten Fahl.

Heft-Nr. 256/1998 – "Das Radionuklid Tritium im Ozean: Meßverfahren und Verteilung von Tritium im Südatlantik und im Weddellmeer", von Jürgen Sültenfuß.

Heft-Nr. 257/1998 – "Untersuchungen der Saisonalität von atmosphärischen Dimethylsulfid in der Arktis und Antarktis", von Christoph Kleefeld.

Heft-Nr. 258/1998 – "Bellinghausen- und Amundsenmeer: Entwicklung eines Sedimentationsmodells", von Frank-Oliver Nitsche.

Heft-Nr. 259/1998 – "The Expedition ANTARKTIS-XIV/4 of RV 'Polarstern' in 1997", by Dieter K. Fütterer.

Heft-Nr. 260/1998 – "Die Diatomeen der Laptevsee (Arktischer Ozean): Taxonomie und biogeographische Verbreitung", von Holger Cremer.

Heft-Nr. 261/1998 – "Die Krustenstruktur und Sedimentdecke des Eurasischen Beckens, Arktischer Ozean: Resultate aus seismischen und gravimetrischen Untersuchungen", von Estella Weigelt.

Heft-Nr. 262/1998 – "The Expedition ARKTIS-XIII/3 of RV 'Polarstern' in 1997", by Gunther Krause.

Heft-Nr. 263/1998 – "Thermo-tektonische Entwicklung von Oates Land und der Shackleton Range (Antarktis) basierend auf Spaltspuranalysen", von Thorsten Schäfer.

Heft-Nr. 264/1998 – "Messungen der stratosphärischen Spurengase ClO, HCl, O_3, N_2O, H_2O und OH mittels flugzeuggetragener Submillimeterwellen-Radiometrie", von Joachim Urban.

Heft-Nr. 265/1998 – "Untersuchungen zu Massenhaushalt und Dynamik des Ronne Ice Shelfs, Antarktis", von Astrid Lambrecht.

Heft-Nr. 266/1998 – "Scientific Cruise Report of the Kara Sea Expedition of RV 'Akademik Boris Petrov' in 1997", edited by Jens Matthiessen and Oleg Stepanets.

Heft-Nr. 267/1998 – "Die Expedition ANTARKTIS-XIV mit FS 'Polarstern' 1997. Bericht vom Fahrtabschnitt ANT-XIV/3", herausgegeben von Wilfried Jokat und Hans Oerter.

Heft-Nr. 268/1998 – "Numerische Modellierung der Wechselwirkung zwischen Atmosphäre und Meereis in der arktischen Eisrandzone", von Gerit Birnbaum.

Heft-Nr. 269/1998 – "Katabatic wind and Boundary Layer Front Experiment around Greenland (KABEG '97)", by Günther Heinemann.

Heft-Nr. 270/1998 – "Architecture and evolution of the continental crust of East Greenland from integrated geophysical studies", by Vera Schlindwein.

Heft-Nr. 271/1998 – "Winter Expedition to the Southwestern Kara Sea - Investigations on Formation and Transport of Turbid Sea-Ice", by Dirk Dethleff, Peter Loewe, Dominik Weiel, Hartmut Nies, Gesa Kuhlmann, Christian Bahe and Gennady Tarasov.

* vergriffen / out of print.

** nur noch beim Autor / only from the author.